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(71) Applicants *(for all designated States except US)*: SCHERING CORPORATION [US/US]; 2000 Galloping Hill Road, Kenilworth, NJ 07033 (US). THE BOARD OF TRUSTEES OF THE LELAND STANFORD JUNIOR UNIVERSITY [US/US]; Suite 350, 900 Welch Road, Palo Alto, CA 94304-1850 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: LITWIN, Virginia, M. [US/US]; 205 Canopus Hollow Road, Putnam Valley, NY 10579 (US). GUMPERZ, Jenny [US/US]; Apartment 7, 427 Wayne Avenue, Oakland, CA 94606 (US). PARHAM, Peter [GB/US]; 734 Alvarado Court, Stanford, CA 94305 (US). PHILLIPS, Joseph, H. [US/US]; 15 Pine Avenue, San Carlos, CA 94070 (US). LANIER, Lewis, L. [US/US]; 1528 Frontero Avenue, Los Altos, CA 94024 (US).

(74) Agents: BLASDALE, John, H. et al.; Schering-Plough Corporation, Patent Dept. K-6-1 1990, 2000 Galloping Hill Road, Kenilworth, NJ 07033-0530 (US).

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(54) Title: ANTIBODIES TO MAMMALIAN NATURAL KILLER ANTIGENS AND USES

(57) Abstract

Antibodies which specifically bind to an NK cell surface antigen from a mammal, reagents related thereto, including purified proteins, specific antibodies, and nucleic acids encoding the antigen. Methods of using the reagents and diagnostic kits are also provided.

ANTIBODIES TO MAMMALIAN NATURAL KILLER ANTIGENS AND USES

FIELD OF THE INVENTION

The present invention relates to compositions which function in controlling physiology, development, and differentiation of mammalian cells, e.g., cells of a mammalian immune system. In particular, it provides antibodies, e.g., agonists and antagonists, which regulate cellular physiology, development, differentiation, or function of various cell types, including hematopoietic cells, and particularly natural killer (NK) and T cells.

BACKGROUND OF THE INVENTION

The immune system of vertebrates consists of a number of organs and several different cell types. Two major cell types include the myeloid and lymphoid lineages. Cells of the lymphoid cell lineage include: B cells, which were originally characterized as differentiating in fetal liver or adult bone marrow; T cells, which were originally characterized as differentiating in the thymus; and natural killer (NK) cells. See Paul (ed.) (1993) Fundamental Immunology (3d ed.), Raven Press, New York.

NK cells are lymphocytes distinct from T and B cells that mediate cell-mediated cytotoxicity and secrete cytokines after immune stimulation, but do not rearrange immunoglobulin (Ig) or T cell receptor (TcR) genes. See Moretta et al. (1994) Adv. Immunol. 55:341-380; and Trinchieri (1989) Adv. Immunol. 47:187-376.

It is becoming increasingly clear that both triggering and inhibitory molecules are involved in NK cell recognition and activation, e.g., dictating their lytic specificity. On the one hand, NK cell effector function involves a positive signal that initiates cytotoxicity and cytokine production. In the case of antibody-dependent cellular cytotoxicity, the positive signal is generated by the interaction between an Ig-coated target and CD16 (FcγRIII) on the NK cell. See Lanier et al. (1983) J. Immunol. 131:1789-1796. However, the membrane receptors responsible for initiating lysis of transformed or virus-infected cells in the absence of specific Ig have not yet been identified.

On the other hand, NK cell-mediated cytotoxicity is also regulated by inhibitory signals. Karre and colleagues initially observed that certain murine tumor variants lacking H-2 antigens were more susceptible to NK lysis, whereas high levels of H-2 expression correlated with resistance. See Karre et al. (1986)

Nature 319:675-678; and Ljunggren et al. (1985) J. Exp. Med. 162:1745-1759. Similarly, when MHC class I molecules were transfected into human HLA-deficient B lymphoblastoid cell lines (B-LCLs), the transfectants were less susceptible to NK cell lysis than the parental lines. See Storkus et al. (1989), Proc. Natl. Acad. Sci. USA 86:2361-2364; and Shimizu et al. (1989) Eur. J. Immunol. 19:447-451. Analysis of an extensive panel of NK cell clones showed that human NK cells have the ability to recognize multiple HLA-A, HLA-B, and HLA-C alleles. See Litwin et al. (1993) J. Exp. Med. 178:1321-1336.

Karre has proposed two models which could account for this phenomenon: 1) target interference; and 2) effector inhibition. The target interference model postulates that target-cell MHC class I molecules mask antigens which could stimulate NK lysis. The effector-inhibition model proposes that target-cell MHC class I molecules may interact with specific receptors on NK cells, transmit a negative signal and prevent the initiation of cytolytic activity. Recent findings support the latter model.

Yokoyama and colleagues have identified a receptor, Ly-49, that is expressed on a subset of murine NK cells. See Karlhofer et al. (1992) Nature 358:66-70. The interaction between Ly-49 and H-2D^d molecules on target cells prevents NK cell-mediated cytotoxicity. Genetic and biochemical characterization of Ly-49 has revealed at least five genes located on murine chromosome 6 which code for type II membrane glycoproteins of the C-type lectin superfamily. A member of the Ly-49 family, SW5E6, appears to be involved in hybrid resistance by mediating the rejection of bone-marrow cells that are HLA-incompatible, i.e., exhibit a different HLA. SW5E6 and Ly-49 are expressed as disulfide-linked homodimers; as yet, there is no evidence for heterodimers between members of the Ly-49 family. In man NK cell receptors for HLA have not as yet been fully characterized, although Moretta and colleagues have described two antigens expressed on NK subsets that appear to correlate with recognition of HLA-C. See Colonna et al. (1992) Proc. Natl. Acad. Sci. USA 89:7983-7985; and Ciccone et al. (1992) J. Exp. Med. 176:963-971. Functional studies have demonstrated that NK clones recognize not only HLA-C but also certain alleles of HLA-A and HLA-B, suggesting the existence of additional receptors.

However, NK cell receptors which are responsible for recognition of HLA have not been identified or characterized. Thus, a need exists to better understand the molecules involved in NK recognition and activation processes, and mechanisms of their action and interaction. The present invention provides useful reagents and methods for using them.

SUMMARY OF THE INVENTION

The present invention is based, in part, upon the discovery of an antibody which defines and recognizes a novel cell antigen found on natural killer (NK) and T cells. This monoclonal antibody is designated DX9 and the antigen it recognizes has been designated NKB1. The invention embraces these antibodies and methods for their use. In addition, it is directed to antigens recognized by these antibodies, along with variants of these proteins, e.g., mutations (muteins) of the natural sequence, species and allelic variants, fusion proteins, chemical mimetics, and other structural or functional analogs. Various uses of these different antibodies and protein compositions are also provided.

The present invention provides antibodies which bind specifically to a mammalian NKB1. In preferred embodiments the mammal is a primate, especially a human being; or the antibodies are a monoclonal antibody, interfere with binding of DX9 to the NKB1, or are labeled, *e.g.*, with a fluorescent label.

The invention also provides methods of detecting a mammalian NKB1, comprising binding these antibodies to NKB1. In various embodiments, the antibody is a labeled antibody or is immobilized to a solid substrate; the NKB1 is expressed on a cell surface; the detecting allows isolation of a cell which comprises a nucleic acid which expresses NKB1; or the detecting further allows purification of NKB1. The invention also embraces a kit for detecting NKB1 with a compartment containing an antibody. In preferred embodiments, the kit is a fluorescence immunoassay kit.

The present invention further provides methods of modulating an immune function mediated by a cell comprising contacting said cell with an antibody described herein. For instance, the modulation can be blocking NK cell activation or be specific for HLA-B mediated functions.

Also embraced herein are methods for analysing an NK cell population, comprising measuring the presence of NKB1. Typically, the measuring is a quantitative determination, e.g., by measuring binding of an antibody to NKB1.

The invention also provides substantially pure mammalian NKB1 antigens. For example, the NKB1 can be purified by immunoaffinity, e.g., using an antibody which binds specifically to a mammalian NKB1. A preferred antibody for this purpose is DX9. Along with full length NKB1, the invention provides fragments which express an immunological epitope of said NKB1 or modulate an immune response, e.g., a response mediated by an NK cell, including an $NKB1^{+}$ cell.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1A shows adult peripheral blood mononuclear cells (PBMC) stained with fluorochrome-conjugated control Ig. Figure 1B shows adult PBMC stained with fluorescein isothiocyanate-conjugated anti-CD56 and phycoerythrin-conjugated DX9 mAb. Figures 1C and 1D represent $NKB1^-$ and $NKB1^+$ NK clones, respectively, stained with phycoerythrin-DX9 monoclonal antibodies (mAb) or phycoerythrin-Ig. Samples were analyzed by flow cytometry. Data are displayed as contour plots (4 decade log scale). Histograms of DX9 mAb-stained cells are superimposed over histograms of Ig control-stained cells (nearest the ordinate).

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

General

The present invention provides antibodies which recognize mammalian proteins which exhibit properties characteristic of functionally significant molecules expressed by NK cells and/or T cells. These antibodies are exemplified in one embodiment by a monoclonal antibody designated DX9.

The mammalian proteins defined by the antibodies are designated NKB1 proteins. The natural proteins should be capable of mediating various physiological responses which would lead to biological or physiological responses in target cells. In particular, NK cells are responsible for immunological rejection of transplanted tissue, e.g., bone marrow transplants. The DX9 antibodies modulate various immunological responses which affect rejection reactions.

Besides the biological activities mediated by NKB1, Table 1 discloses physical characteristics which enable the protein to be distinguished from others:

TABLE 1: PHYSICAL PROPERTIES OF HUMAN NKB1 MARKERS.

NKB1 markers bind with specificity to DX9 monoclonal antibody
Molecular weight of NKB1 core protein is ~50 kD
Molecular weight of glycosylated form of protein is ~70 kD, whether reduced or non-reduced
Natural form of protein contains sialic acid residues
Natural form of protein contains complex N-linked oligosaccharides
Natural form is typically phosphorylated
NKB1 markers are expressed on a subset of NK cells
NKB1 markers are expressed on a subset of T cells

Antibodies

Antibodies can be raised to the various NKB1 proteins, including species or allelic variants, and fragments thereof. Additionally, antibodies can be raised to NKB1 proteins in either their active forms or their inactive forms. Anti-idiotypic antibodies are also contemplated.

Antibodies, including binding fragments, e.g., Fab, $F(ab)_2$, or F_V fragments (see Moore et al. U.S. Patent No. 4,643,334) and single chain versions against predetermined fragments of the antigens can be raised by immunization of animals with conjugates of the fragments with immunogenic proteins. Polyclonal or monoclonal antibodies are prepared from cells secreting the desired antibody. These antibodies can be screened for binding to normal or defective NKB1 proteins, or screened for agonistic or antagonistic activity, e.g., mediated through a binding partner or counter-receptor. These monoclonal antibodies usually bind with a K_D of at most about 1 mM but more usually with stronger binding, e.g., with a K_D of at most about 300 μM, typically at most about 100 μM, more typically at most about 30 μM, preferably at most about 10 μM, and more preferably at most about 3 μM or better.

The antibodies of this invention, including antigen-binding fragments, can have significant diagnostic or therapeutic value. They can be potent antagonists that bind to NKB1 and inhibit interaction with a binding partner or inhibit the ability of the interaction to mediate a biological response. They also can be useful as non-neutralizing antibodies and can be coupled to toxins or radionuclides, so that, when the antibody binds to the antigen, a cell expressing the antigen (e.g., on its surface) is killed. Further, these antibodies can be

conjugated to drugs or other therapeutic agents, either directly or indirectly by means of a linker, and may effect drug targeting.

The antibodies of this invention can also be useful in diagnostic applications. As antibodies that capture or bind the antigen without neutralizing it, they can be screened for ability to bind the antigen without inhibiting binding by a binding partner. As neutralizing antibodies, they can be useful in competitive binding assays. They are also useful in detecting or quantifying NKB1 protein or its binding partners, and in evaluating cell populations to determine, e.g., the physiological state of an immune system.

Antigen fragments may be joined to other materials, particularly polypeptides, as fused or covalently joined polypeptides to be used as immunogens. The antigen may be purified by methods described below, including immunoaffinity methods using antibodies, e.g., DX9. An antigen and its fragments may be fused or covalently linked to a variety of immunogens, such as keyhole limpet hemocyanin, bovine serum albumin, tetanus toxoid, etc. For descriptions of methods of preparing polyclonal antisera, see, e.g., Microbiology, Hoeber Medical Division, Harper and Row, 1969; Landsteiner (1962), Specificity of Serological Reactions, Dover Publications, New York; and Williams et al. (1967) Methods in Immunology and Immunochemistry Vol. 1, Academic Press, New York. A typical method involves hyperimmunization of an animal with an antigen. The blood of the animal is then collected shortly after the repeated immunizations and the gamma globulin is isolated.

Sometimes it is desirable to prepare monoclonal antibodies from various mammalian hosts, such as mice, rodents, primates, humans, etc. Description of techniques for preparing such monoclonal antibodies may be found in, e.g., Stites et al. (eds.), Basic and Clinical Immunology (4th ed.), Lange Medical Publications, Los Altos, CA, and references cited therein; Harlow and Lane (1988) Antibodies: A Laboratory Manual, CSH Press; Goding (1986), Monoclonal Antibodies: Principles and Practice (2d ed.), Academic Press, New York; and particularly in Kohler and Milstein (1975) in Nature 256:495-497, which discusses one method of generating monoclonal antibodies. Summarized briefly, this method involves injecting an animal with an immunogen. The animal is then sacrificed and cells are taken from its spleen, which are then fused with myeloma cells. The result is a hybrid cell or "hybridoma" that is capable of reproducing in vitro. The population of hybridomas is then screened to isolate individual clones, each of which secretes a single antibody species to the immunogen. In this manner, the individual antibody species obtained are the products of immortalized and cloned single

B cells from the immunized animal generated in response to a specific epitope recognized on the immunogenic substance.

Other suitable techniques involve in vitro exposure of lymphocytes to the antigenic polypeptides or, alternatively, selection of libraries of antibodies in phage or similar vectors. See Huse et al. (1989) "Generation of a Large Combinatorial Library of the Immunoglobulin Repertoire in Phage Lambda", Science 246:1275-1281; and Ward et al. (1989) Nature 341:544-546. The polypeptides and antibodies of the present invention may be used with or without modification, for example as chimeric or humanized antibodies. Frequently, the polypeptides and antibodies will be labeled by joining, either covalently or non-covalently, a substance which provides for a detectable signal. A wide variety of labels and conjugation techniques are known and are reported extensively in both the scientific and patent literature. Suitable labels include radionuclides, enzymes, substrates, cofactors, inhibitors, fluorescent moieties, chemiluminescent moieties, magnetic particles, and the like. Patents teaching use of such labels include U.S. Patent Nos. 3,817,837; 3,850,752; 3,939,350; 3,996,345; 4,277,437; 4,275,149; and 4,366,241. Also, recombinant immunoglobulins may be produced. See Cabilly, U.S. Patent No. 4,816,567.

The antibodies of this invention can also be used for affinity chromatography in isolating the protein. Columns can be prepared where the antibodies are linked to a solid support, e.g., particles, such as agarose, SEPHADEX, or the like, where a cell lysate may be passed through the column, and the column is washed and then eluted with increasing concentrations of a mild denaturant, whereby the purified NKB1 protein will be released. Alternatively, the antibody may be used to quantitate and identify fractionated samples containing the antigen. Standard protein-purification procedures, e.g., chromatography, will be used to enrich and purify NKB1 protein with, e.g., ELISA assays, to identify fractions where NKB1 separates. Purified protein will be useful for sequencing to determine oligonucleotide sequences useful as primers or probes.

The antibodies may also be used to screen expression libraries for particular expression products. Usually the antibodies used in such a procedure will be labeled with a moiety allowing easy detection of presence of antigen by antibody binding. This will allow isolation of a cell which expresses a nucleic acid, e.g., a vector, encoding the antigen by, e.g., fluorescence-activated cell sorting (FACS) analysis, and enrichment. Alternatively, an affinity method using antibodies of this invention can be used to immobilize and separate cells expressing the NKB1, e.g., encoded on a vector.

Antibodies raised against each NKB1 protein will also be useful to raise anti-idiotypic antibodies. These will be useful in detecting or diagnosing various immunological conditions related to expression of the respective antigens.

Purified NKB1 protein

Human NKB1 protein can be isolated from natural sources using standard biochemical purification techniques and/or by use of the antibody to determine the presence of the antigen in particular fractionation procedures. The proteins allow both sequence determination and preparation of peptides to generate antibodies that recognize such peptide segments. As used herein, NKB1 shall encompass, when used in the context of a protein derived from a human, a protein which, in its natural state, exhibits the properties listed in Table 1, or a significant fragment of such a protein. It also refers to a mammalian-derived, e.g., primate-derived, polypeptide which exhibits similar biological function or interacts with specific binding components of NKB1 protein. These binding components, e.g., antibodies, typically bind to an NKB1 protein with high affinity, e.g., at better than about 100 nM, preferably at better than about 30 nM or about 10 nM, and more preferably at better than about 3 nM. One such preferred binding component is the antibody DX9.

The purified protein or peptide fragments are useful for generating antibodies by standard methods, as described below. Synthetic peptides or purified protein can be presented to an immune system to generate a specific binding composition, e.g., monoclonal or polyclonal antibodies. See, e.g., Coligan (1991) Current Protocols in Immunology, Wiley/Greene; and Harlow and Lane (1989) Antibodies: A Laboratory Manual, Cold Spring Harbor Press.

The term 'polypeptide', as used herein, includes a significant fragment or segment, and encompasses a stretch of amino acid residues of at least about 8 amino acids, generally at least 12 or 16 amino acids, preferably at least 20 or 24 amino acids, and, in particularly preferred embodiments, at least 28 or even 30 or more amino acids. The specific ends of such a segment will be at any combinations within the protein. Preferably, the fragment exhibits a biological property in common with the full length NKB1, e.g., immunological activity, including sharing of an epitope.

'Substantially pure', relating to a polypeptide or protein, typically means that the polypeptide or protein is free from contaminating proteins, nucleic acids, and/or other biologicals derived from the original source organism. Purity may be assayed by standard methods; the polypeptide or protein will ordinarily be at

least about 40% pure, generally at least about 50% or 60% pure, often at least about 70% or 75% pure, typically at least about 80% or 85% pure, preferably at least about 90% or 95% pure, and in most preferred embodiments at least about 98% or especially 99% pure. The analysis may be weight or molar percentages, evaluated, e.g., by gel staining, spectrophotometry, or terminus labeling.

A 'binding composition' refers to molecules that bind with specificity to NKB1 protein, e.g., in a ligand-receptor type fashion, an antibody-antigen interaction, or compounds, e.g., proteins, which specifically associate with NKB1 protein, e.g., in a natural physiologically relevant protein-protein interaction, either covalent or non-covalent. The molecule may be a polymer, or chemical reagent. No implication as to whether NKB1 protein is either the ligand or the receptor of a ligand-receptor interaction is represented, other than that the interaction exhibits similar specificity, e.g., specific affinity. This implies both binding affinity and binding specificity. A functional analog may be a protein with structural modifications, or may be a wholly unrelated molecule, e.g., which has a molecular shape which interacts with the appropriate binding determinants. The proteins may serve as agonists or antagonists of a receptor. See, e.g., Goodman et al. (eds.) (1990) Goodman & Gilman's: The Pharmacological Bases of Therapeutics (8th ed.), Pergamon Press, Tarrytown, N.Y.

Soluble fragments of both the antibodies and NKB1 antigens are provided by the invention. Solubility of a polypeptide or fragment depends upon the environment and the polypeptide. Many factors affect polypeptide solubility, including temperature, electrolyte environment, size and molecular characteristics of the polypeptide, and nature of the solvent. Typically, the temperature at which the polypeptide is used ranges from about 4°C to about 65°C, and is usually higher than about 18°C and more usually higher than about 22°C. For diagnostic purposes, the temperature will usually be about room temperature or higher, but lower than the denaturation temperature of components in the assay. For therapeutic purposes, the temperature will usually be body temperature, typically about 37°C for humans, though under certain situations the temperature may be raised or lowered in situ or in vitro.

The electrolytes will usually approximate in situ physiological conditions, but may be modified to higher or lower ionic strength where advantageous. The actual ions may be modified, e.g., to conform to standard buffers used in physiological or analytical contexts.

The polypeptide should generally be in a substantially stable state, and usually not in a denatured state. The polypeptide may be associated with other polypeptides in a quaternary structure, e.g., to confer solubility, or associated

with lipids or detergents in a manner which approximates natural lipid bilayer interactions.

The solvent will usually be a biologically compatible buffer, of a type used for preservation of biological activities, and will usually approximate a physiological solvent. Usually the solvent will have a roughly neutral pH, typically between about 5 and 10, and preferably about 7.5. On some occasions, a detergent will be added, typically a mild non-denaturing one, e.g., CHS (cholestanyl hemisuccinate) or CHAPS (3-[(3-cholamidopropyl)-dimethylammonio]-1-propanesulfonate), in a low enough concentration to avoid significant disruption of structural or physiological properties of the antigen.

Solubility is reflected by sedimentation measured in Svedberg units, which are a measure of the sedimentation velocity of a molecule under particular conditions. The determination of the sedimentation velocity was classically performed in an analytical ultracentrifuge, but typically is now performed in a standard ultracentrifuge. See Freifelder (1982) Physical Biochemistry (2d ed.) W.H. Freeman; and Cantor and Schimmel (1980) Biophysical Chemistry parts 1-3, W.H. Freeman & Co., San Francisco. As a crude determination, a sample containing a putatively soluble polypeptide is spun in a standard full sized ultracentrifuge at about 50K rpm for about 10 minutes, and soluble molecules will remain in the supernatant. A soluble particle or polypeptide will typically be less than about 30S, usually less than about 10S, and, in particular embodiments, less than about 4S, and preferably less than about 3S.

Physical Variants

This invention also encompasses proteins or peptides having substantial amino acid sequence homology with a natural mammalian NKB1 protein or an antibody described above. The variants include species variants and allelic variants. A person having ordinary skill in the art will recognize that much of the following discussion of variants will apply to variants of both the NKB1 antigen and the antibodies which recognize it.

Homology of two (or more) amino acid sequences, or degree of sequence identity, is determined by optimizing residue matches, if necessary by introducing gaps as required. This changes when substitutions with conservative amino acid residues are regarded as matches. Conservative substitutions typically include substitutions within the following groups: glycine, alanine; valine, isoleucine, leucine; aspartic acid, glutamic acid; asparagine,

glutamine; serine, threonine; lysine, arginine; and phenylalanine, tyrosine. Homologous amino acid sequences are typically intended to include natural allelic and interspecies variations in each respective protein sequence. Typical homologous proteins or peptides will have from 25-100% homology (if gaps can be introduced), to 50-100% homology (if conservative substitutions are included) with the amino acid sequence of the NKB1 protein. Homology measures will be at least about 35%, generally at least about 40% or 50%, often at least about 60% or 70%, preferably at least about 80%, and in particularly preferred embodiments, at least about 85% or more. See also Needleham et al. (1970) J. Mol. Biol. 48:443-453; Sankoff et al. (1983), Chapter One in Time Warps, String Edits, and Macromolecules: The Theory and Practice of Sequence Comparison, Addison-Wesley, Reading, MA; and software packages from IntelliGenetics, Mountain View, CA; and the University of Wisconsin Genetics Computer Group, Madison, WI.

An isolated DNA, isolated as described below, encoding an NKB1 protein can be readily modified by nucleotide substitutions, nucleotide deletions, nucleotide insertions, and inversions of nucleotide stretches. These modifications result in novel DNA sequences which encode these antigens, their derivatives, or proteins having similar physiological, immunogenic, or antigenic activity. These modified sequences can be used to produce mutant antigens or to enhance expression. Enhanced expression may involve gene amplification, increased transcription, increased translation, and other mechanisms. Such mutant NKB1 protein derivatives include predetermined or site-specific mutations of the respective protein or its fragments. "Mutant NKB1 protein" encompasses a polypeptide otherwise falling within the homology definition of the human NKB1 protein as set forth above, but having an amino acid sequence which differs from that of NKB1 protein as found in nature, whether by way of deletion, substitution, or insertion. In particular, "site-specific mutant NKB1 protein" generally includes proteins having significant homology with a natural protein with properties described in Table 1, and/or sharing various biological activities, e.g., antigenic or immunogenic, with those sequences, and in preferred embodiments includes in particular natural forms of the proteins which may have a single substitution, a single deletion, and/or a single insertion. Similar concepts apply to different NKB1 proteins, particularly those found in various mammals, e.g., primates, including humans. As stated before, it is emphasized that the descriptions are generally meant to encompass all mammalian NKB1 proteins.

Although site-specific mutation sites are predetermined, mutants need not be site-specific. NKB1 protein mutagenesis can be conducted by substitution, deletion or insertion of amino acids. Substitutions, deletions, insertions, or any combinations may be generated to arrive at a final construct. Insertions include amino- or carboxy-terminal fusions. Random mutagenesis of DNA can be conducted at a target codon, and the expressed mutants can be screened for the desired activity. Methods for making substitution mutations at predetermined sites in DNA having a known sequence are well known in the art, e.g., by M13 primer mutagenesis or polymerase chain reaction (PCR) techniques. See also Sambrook et al. (1989) and Ausubel et al. (1987 and Supplements).

The mutations in the DNA normally should not place coding sequences out of reading frames and preferably will not create complementary regions that could hybridize to produce secondary mRNA structures such as loops or hairpins.

The phosphoramidite method described by Beaucage and Carruthers (1981) Tetra. Letts. 22:1859-1862, will produce suitable synthetic DNA fragments. A double-stranded fragment will often be obtained either by synthesizing the complementary strand and annealing the strand together under appropriate conditions or by adding the complementary strand using DNA polymerase with an appropriate primer sequence, e.g., PCR techniques.

The present invention also provides recombinant proteins, e.g., heterologous fusion proteins using segments from these proteins. A heterologous fusion protein is a fusion of proteins or segments which in nature are not normally fused in the same manner. Thus, the fusion product of an immunoglobulin with an NKB1 polypeptide is a continuous protein molecule having sequences fused in a typical peptide linkage, typically made as a single translation product and exhibiting properties derived from each source peptide. A similar concept applies to heterologous nucleic acid sequences.

In addition, new constructs may be made from combining similar functional domains from other proteins. For example, antigen-binding or other segments may be "swapped" between different new fusion polypeptides or fragments. See, e.g., Cunningham et al. (1989) Science 243:1330-1336; and O'Dowd et al. (1988) J. Biol. Chem. 263:15985-15992. Thus, new chimeric polypeptides exhibiting new combinations of specificities will result from the functional linkage of biologically relevant domains and other functional domains.

Functional Variants

The blocking of physiological response mediated by NKB1 proteins may result from the inhibition of binding of the antigen to its natural binding partner, e.g., through competitive inhibition. Thus, in vitro assays of the present invention will often use isolated protein, membranes from cells expressing a recombinant membrane associated NKB1 protein, soluble fragments comprising binding segments, or fragments attached to solid phase substrates. These assays will also allow for the diagnostic determination of the effects of either binding segment mutations and modifications, or protein mutations and modifications, e.g., analogs. In particular, the NKB1 is stably expressed on NK clones, but the antigen is lost after activation of T cells; T cell clones are negative.

This invention also contemplates the use of competitive drug screening assays, e.g., where neutralizing antibodies to antigen or binding partner fragments compete with a test compound for binding to the protein. In this manner, the antibodies can be used to detect the presence of any polypeptide which shares one or more antigenic binding sites of the protein and can also be used to occupy binding sites on the protein that might otherwise interact with a binding partner.

Additionally, neutralizing antibodies against the NKB1 protein and soluble fragments of the antigen which contain a high-affinity receptor-binding site can be used to inhibit antigen function in tissues, e.g., tissues experiencing abnormal or undesired physiology. For instance, DX9 antibody may stimulate activation of NK cells which may modulate undesired tissue rejection after transplantation.

"Derivatives" of the NKB1 antigens, and of antibodies, include amino acid sequence mutants, glycosylation variants, and covalent or aggregate conjugates with other chemical moieties. Covalent derivatives can be prepared by linkage of functionalities to groups which are found in the NKB1 amino acid side chains or at the N- or C-termini, by means which are well known in the art. These derivatives can include, without limitation, aliphatic esters or amides of the carboxyl terminus, or of residues containing carboxyl side chains, O-acyl derivatives of residues containing a hydroxyl group, and N-acyl derivatives of the amino-terminal amino acid or of residues containing an amino-group, e.g., lysine or arginine. Acyl groups are preferably selected from the group of alkanoyl moieties including C2 to C18 normal alkanoyl. Covalent attachment to carrier proteins may be important when immunogenic moieties are haptens.

In particular, "derivatives" of the NKB1 antigens includes those with modified glycosylation, e.g., those whose glycosylation patterns were modified during synthesis and processing, or in further processing steps. Particularly preferred means for accomplishing this are by exposing the polypeptide to glycosylating enzymes derived from cells which normally provide such processing, e.g., mammalian glycosylation enzymes, or to deglycosylation enzymes. Cell lines may be selected which produce differently glycosylated versions of the protein, including a recombinant protein. Also embraced are versions of the same primary amino acid sequence which have other minor modifications, including phosphorylated amino acid residues, e.g., phosphotyrosine, phosphoserine, or phosphothreonine.

A major group of derivatives comprises covalent conjugates of the NKB1 protein or fragments thereof with other proteins or polypeptides. Such derivatives can be synthesized in recombinant culture as N- or C-terminal fusions. Alternatively, they can be formed by coupling the NKB1 protein or fragments thereof with agents known in the art for their usefulness in cross-linking proteins through reactive side groups. Preferred sites for forming derivatives of the protein with cross-linking agents are at free amino groups, carbohydrate moieties, and cysteine residues.

Fusion polypeptides between the NKB1 proteins and other homologous or heterologous proteins are also provided. Homologous polypeptides may be fusions between different surface markers, resulting in, e.g., a hybrid protein exhibiting receptor-binding specificity. Likewise, heterologous fusions may be constructed which would exhibit a combination of properties or activities of the derivative proteins. Typical examples are fusions of a reporter polypeptide, e.g., luciferase, with a segment or domain of an antigen, e.g., a receptor-binding segment, so that the presence or location of the fused antigen may be easily determined. See, e.g., Dull et al., U.S. Patent No. 4,859,609. Other gene fusion partners include bacterial β-galactosidase, trpE, Protein A, β-lactamase, alpha amylase, alcohol dehydrogenase, and yeast alpha mating factor. See, e.g., Godowski et al. (1988) Science 241:812-816.

Such polypeptides may also have amino acid residues which have been chemically modified by phosphorylation, sulfonation, biotinylation, or the addition or removal of other moieties, particularly those which have molecular shapes similar to phosphate groups. In some embodiments, the modifications will be useful labeling reagents, or serve as purification targets, e.g., affinity ligands.

Fusion proteins will typically be made either by recombinant nucleic acid methods or by synthetic polypeptide methods. Techniques for nucleic acid manipulation and expression are described generally, for example, in Sambrook et al. (1989) Molecular Cloning: A Laboratory Manual (2d ed.), Vols. 1-3, Cold Spring Harbor Laboratory. Techniques for synthesis of polypeptides are described in, for example: Merrifield (1963) J. Amer. Chem. Soc. 85:2149-2156; Merrifield (1986) Science 232: 341-347; and Atherton et al. (1989) Solid Phase Peptide Synthesis: A Practical Approach, IRL Press, Oxford.

This invention also contemplates the use of derivatives of the NKB1 proteins other than those characterized by variations in amino acid sequence or glycosylation. Such derivatives may be formed by covalent or aggregative association with chemical moieties. These derivatives generally fall into the three classes: (1) salts, (2) side-chain and terminal-residue covalent modifications, and (3) adsorption complexes, for example with cell membranes. Such covalent or aggregative derivatives are useful as immunogens, as reagents in immunoassays, or in purification methods, e.g., in affinity purification of antigens or other binding proteins. For example, an NKB1 antigen can be immobilized by covalent bonding to a solid support such as cyanogenbromide-activated SEPHAROSE, by methods which are well known in the art, or adsorbed onto polyolefin surfaces, with or without glutaraldehyde cross-linking, for use in the assay or purification of anti-NKB1-protein antibodies or NKB1-protein receptor or other binding partner. The NKB1 antigens can also be labeled with a detectable group, for example radioiodinated by the chloramine-T procedure, covalently bound to rare earth chelates, or conjugated to another fluorescent moiety for use in diagnostic assays. Purification of NKB1 protein may be effected by immobilized antibodies or binding partners.

A solubilized NKB1 antigen or fragment of this invention can be used as an immunogen for the production of antisera or antibodies specific for the protein or fragments thereof. The purified antigen can be used to screen monoclonal antibodies or binding fragments prepared by immunization with various forms of impure preparations containing the protein. In particular, antigen-binding fragments of natural antibodies are often equivalent to the antibodies themselves. The purified NKB1 proteins can also be used as a reagent to detect any antibodies generated in response to the presence of elevated levels of the protein or cell fragments containing the antigen, each of which may be diagnostic of an abnormal or specific physiological or disease condition. Additionally, antigen fragments may also serve as immunogens to produce further antibodies of the present invention, as described immediately

below. For example, this invention contemplates antibodies raised against amino acid sequences from proteins having properties described in Table 1, or fragments of them. In particular, this invention contemplates antibodies having binding affinity to or raised against specific fragments which are predicted to lie outside of the lipid bilayer, e.g., intact domain structures.

The invention also provides means to isolate a group of related antigens displaying both distinctness and similarities in structure, expression, and function. Elucidation of many of the physiological effects of the antigens will be greatly accelerated by the isolation and characterization of distinct species variants. In particular, the present invention provides useful probes for identifying additional homologous genetic entities in different species.

Isolated genes will allow transformation of cells lacking expression of a corresponding NKB1 protein, e.g., either species types or cells which lack corresponding antigens and should exhibit negative background biological activity. Expression of transformed genes will allow isolation of antigenically pure cell lines, with defined or single species variants. This approach will allow for more sensitive detection and discrimination of the physiological effects of NKB1 proteins. Subcellular fragments, e.g., cytoplasts or membrane fragments, can be isolated and used.

Dissection of the critical structural elements which affect the various physiological or differentiation functions provided by the proteins is possible using standard techniques of modern molecular biology, particularly in comparing members of the related class. See, e.g., the homolog-scanning mutagenesis technique described in Cunningham et al. (1989) Science 243:1339-1336; and approaches used in O'Dowd et al. (1988) J. Biol. Chem., 263:15985-15992; and in Lechleiter et al. (1990) EMBO J. 9:4381-4390.

In particular, functional domains or segments can be exchanged between species variants or related proteins to determine what structural features are important in both binding partner affinity and specificity, as well as signal transduction. An array of different variants will be useful to screen for molecules exhibiting combined properties of interaction with different species variants of binding partners.

Antigen internalization may occur under certain circumstances, and interaction between intracellular components and "extracellular" segments of proteins involved in interactions may occur. The specific segments of interaction of NKB1 protein with other intracellular components may be identified by mutagenesis or direct biochemical means, e.g., cross-linking or affinity methods. Structural analysis by crystallographic or other physical methods will also be

applicable. Further investigation of the mechanism of biological function will include study of associated components which may be isolatable by affinity methods or by genetic means, e.g., complementation analysis of mutants.

Expression of NKB1 in other cell types will often result in glycosylation differences of a particular antigen. Various species variants may exhibit distinct functions based upon structural differences other than amino acid sequence. Differential modifications may be responsible for differential function, and elucidation of the effects are now made possible.

Thus, the present invention provides important reagents related to antigen-binding partner interaction. Although the foregoing description has focused primarily upon the human NKB1 protein, those of skill in the art will immediately recognize that the invention encompasses other closely related antigens, e.g., other primate species or allelic variants, as well as variants and other members of the family.

DNA encoding such modified polypeptides of the present invention can be prepared by standard methods, *e.g.* by the phosphoramidite method mentioned in the previous section or by methods described in the next section.

<u>Nucleic Acids</u>

Table 1 discloses the properties of natural NKB1 protein which allow for purification of the protein. This provides means to isolate nucleic acids encoding such proteins, and determination of the sequence provides a handle on other members of the NKB1 family. Such nucleotide sequences and related reagents are useful in constructing a DNA clone useful for expressing NKB1 protein, or, e.g., for isolating a homologous gene from another natural source, including other members of the family. Typically, the sequences will be useful in isolating other genes, e.g., allelic variants or alternatively spliced isoforms, from humans.

For example, a specific binding composition such as DX9 could be used for screening of an expression library made from a cell line which expresses an NKB1 protein. The screening can use standard staining of surface-expressed protein, or panning. Screening of intracellular expression can also be performed by various staining or immunofluorescence procedures. The binding compositions could be used in affinity purification of cells expressing the protein or in sorting out such cells.

This invention contemplates use of isolated DNA or fragments to encode a biologically active NKB1 protein or polypeptide. In addition, this invention

covers isolated or recombinant DNA which encodes a biologically active protein or polypeptide and which is capable of hybridizing under appropriate conditions with the DNA sequences. Said biologically active protein or polypeptide can be a full-length antigen, or a fragment thereof. Further, this invention covers the use of isolated or recombinant DNA, or fragments thereof, which encode proteins which are homologous to an NKB1 protein or which were isolated using cDNA encoding an NKB1 protein as a probe. The isolated DNA can have the respective regulatory sequences in the 5'- and 3'-flanks, e.g., promoters, enhancers, poly-A addition signals, and others.

An "isolated" nucleic acid is a nucleic acid, e.g., an RNA, DNA, or a mixed polymer, which is substantially separated from other components that naturally accompany a native sequence, e.g., ribosomes, polymerases, and flanking genomic sequences from the originating species. The term embraces a nucleic acid sequence which has been removed from its naturally occurring environment, and includes recombinant or cloned DNA isolates and chemically synthesized analogs or analogs biologically synthesized by heterologous systems. A substantially pure molecule includes isolated forms of the molecule. Alternatively, a purified species may be separated from host components from a recombinant expression system.

An isolated nucleic acid will generally be a homogeneous composition of molecules, but will, in some embodiments, contain minor heterogeneity. This heterogeneity is typically found at the ends of the nucleic acid molecule or at portions not critical to a desired biological function or activity.

A "recombinant" nucleic acid is defined either by its method of production or by its structure. In reference to its method of production, e.g., a process for making it, the process is use of recombinant nucleic acid techniques, e.g., involving human intervention in the nucleotide sequence, typically selection or production. In reference to its structure, it can be a nucleic acid consisting of two fused fragments which are not naturally contiguous to each other, but it is meant to exclude products of nature, e.g., naturally occurring mutants. Thus, for example, unnaturally occurring vectors made for transforming cells are encompassed, as are the transformed cells themselves, and also nucleic acids comprising sequences derived using any synthetic oligonucleotide process. Such a process is often used to replace a codon with a redundant codon encoding the same amino acid or a conservative amino acid substitution, while typically introducing or removing a sequence-recognition site. Alternatively, this is performed to join together nucleic acid segments of desired functions to generate a single genetic entity comprising a desired combination of functions

not found in the commonly available natural forms. Restriction-enzyme recognition sites are often the target of such artificial manipulations, but other site-specific targets, e.g., promoters, DNA replication sites, regulation sequences, control sequences, or other useful features may be incorporated by design. (A similar concept also applies to a recombinant polypeptide, e.g., a fusion polypeptide.) Specifically included are synthetic nucleic acids which, by genetic code redundancy, encode polypeptides similar to fragments of these antigens, and fusions of sequences from various different species variants.

A significant "fragment" in a nucleic acid context is a contiguous segment of at least about 17 nucleotides, generally at least 23 or 29 nucleotides, often at least 35 or 41 nucleotides, preferably at least 47 or 53 nucleotides, and in particularly preferred embodiments will be of 56 or more nucleotides. Said fragments may have termini at any location, but especially at boundaries between the structural domains.

A DNA which codes for an NKB1 protein will be particularly useful to identify genes, mRNA, and cDNA species which code for related or homologous proteins, as well as DNAs which code for homologous proteins. Homologs should occur in other mammals, e.g., primates. Various NKB1 proteins should be homologous and are encompassed herein. However, even proteins that have a more distant evolutionary relationship to the antigen can readily be isolated under appropriate conditions using these sequences if they are sufficiently homologous. Primate NKB1 proteins are of particular interest.

This invention further covers recombinant DNA molecules and fragments having a DNA sequence identical to or highly homologous to the isolated DNAs set forth herein. In particular, the sequences will often be operably linked to DNA segments which control transcription, translation, and DNA replication. Alternatively, recombinant clones derived from the genomic sequences, e.g., containing introns, will be useful for transgenic studies, including, e.g., transgenic cells and organisms, and for gene therapy. See, e.g., Goodnow (1992), "Transgenic Animals" in Roitt (ed.) Encyclopedia of Immunology, Academic Press, San Diego, pp. 1502-1504; Travis (1992) Science 256:1392-1394; Kuhn et al. (1991) Science 254:707-710; Capecchi (1989) Science 244:1288; Robertson (1987) (ed.) Teratocarcinomas and Embryonic Stem Cells: A Practical Approach, IRL Press, Oxford; Rosenberg (1992) J. Clinical Oncology 10:180-199; and Cournoyer and Caskey (1993) Ann. Rev. Immunol. 11:297-329.

Homologous nucleic acid sequences, when compared, exhibit significant similarity. The standards for homology in nucleic acids either are measures for

homology generally used in the art by sequence comparison or are based upon hybridization conditions. The hybridization conditions are described in greater detail below.

Substantial homology in the context of comparing nucleic acid sequences means that the segments are identical when optimally aligned, allowing for appropriate nucleotide insertions or deletions, in at least about 50% or even 59% of the nucleotides, generally at least 65% or even 71%, usually at least about 77% or even 85%, preferably at least about 95 to 98% or more, and, in particular embodiments, as many as about 99% or more of the nucleotides. The comparison can also be made with a complementary strand on the basis of the specific nucleotide pairing that dsDNA uses. Homology can be measured on segments of various lengths or even on two or more of such segments. Alternatively, substantial homology exists when the segments will hybridize under selective hybridization conditions, to a strand, or its complement, typically using a sequence as described. Typically, selective hybridization will occur when there is at least about 55% complementarity over a stretch of at least about 14 nucleotides, preferably at least about 65%, more preferably at least about 75%, and most preferably at least about 90%. See Kanehisa (1984), Nuc. Acids Res., 12:203-213. Sometimes, the comparison (for purposes of determining homology) may be over longer stretches, *e.g.*, over a stretch of at least about 17 nucleotides, usually at least about 24 nucleotides, typically at least about 50 nucleotides, and more preferably at least about 75 to 100 or more nucleotides.

"Stringent conditions", in referring to hybridization in the context of homology, or (more precisely) in the context of complementarity, will be stringent combined conditions of salt, temperature, organic solvents, and other variables, typically those controlled in hybridization reactions. Stringent temperature conditions will usually mean temperatures in excess of about 30°C, typically in excess of about 45°C, preferably in excess of about 65°C, and more preferably in excess of about 70°C. Stringent salt conditions will ordinarily be less than about 1000 mM, usually less than about 500 mM, typically less than about 300 mM, preferably less than about 200 mM, and more preferably less than about 150 mM. However, the combination of variables is much more important than the measure of any single variable. See, e.g., Wetmur and Davidson (1968) J. Mol. Biol. 31:349-370.

Making NKB1 protein: Mimetics

DNA which encodes the NKB1 protein or fragments thereof can be obtained by chemical synthesis, by screening cDNA libraries, or by screening genomic libraries prepared from a wide variety of cell lines or tissue samples.

This DNA can be expressed in a wide variety of host cells for the synthesis of a full-length protein or fragments which can in turn be used, e.g., to generate polyclonal or monoclonal antibodies; in binding studies; in construction and expression of modified molecules; and in structure/function studies. Each antigen or its fragments can be expressed in host cells that are transformed or transfected with appropriate expression vectors. These molecules can be substantially purified to be free of protein or cellular contaminants, other than those derived from the recombinant host, and therefore are particularly useful in pharmaceutical compositions when combined with a pharmaceutically acceptable carrier and/or diluent. The antigen, or portions thereof, may be expressed as fusions with other proteins.

Expression vectors are typically self-replicating DNA or RNA constructs containing the gene for the desired antigen or its fragments, usually operably linked to suitable genetic control elements that are recognized by a suitable host cell. These control elements are capable of effecting expression within a suitable host. The specific type of control elements necessary to effect expression will depend upon the host cell used. Generally, the genetic control elements can include a prokaryotic promoter system or a eukaryotic promoter expression control system, and typically include a transcriptional promoter, an optional operator to control the onset of transcription, transcription enhancers to elevate the level of mRNA expression, a sequence that encodes a suitable ribosome binding site, and sequences that terminate transcription and translation. Expression vectors also usually contain an origin of replication that allows the vector to replicate independently of the host cell.

The vectors of this invention contain DNA which encodes an NKB1 protein, or a fragment thereof, preferably encoding a biologically active polypeptide. The DNA can be under the control of a viral promoter and can encode a selection marker. This invention further contemplates use of such expression vectors which are capable of expressing eukaryotic cDNA coding for an NKB1 protein in a prokaryotic or eukaryotic host, where the vector is compatible with the host and where the eukaryotic cDNA coding for the antigen is inserted into the vector such that growth of the host containing the vector expresses the cDNA in question. Usually, expression vectors are designed for

stable replication in their host cells or for amplification to greatly increase the total number of copies of the desirable gene per cell. It is not always necessary to require that an expression vector replicate in a host cell, e.g., it is possible to effect transient expression of the antigen or its fragments in various hosts using vectors that do not contain a replication origin that is recognized by the host cell. It is also possible to use vectors that cause integration of an NKB1 gene or its fragments into the host DNA by recombination, or to integrate a promoter which controls expression of an endogenous gene.

Vectors, as used herein, comprise plasmids, viruses, bacteriophages, integratable DNA fragments, and other vehicles which enable the integration of DNA fragments into the genome of the host. Expression vectors are specialized vectors which contain genetic control elements that effect expression of operably linked genes. Plasmids are the most commonly used form of vector, but all other forms of vectors which serve an equivalent function and which are, or become, known in the art are suitable for use herein. See, e.g., Pouwels et al. (1985 and Supplements) Cloning Vectors: A Laboratory Manual, Elsevier, N.Y.; and Rodriquez et al. (1988) (eds.) Vectors: A Survey of Molecular Cloning Vectors and Their Uses, Butterworths, Boston, MA.

Transformed cells include cells, preferably mammalian, that have been transformed or transfected with vectors containing an NKB1 gene, typically constructed using recombinant DNA techniques. Transformed host cells usually express the antigen or its fragments; however, for purposes of cloning, amplifying, and manipulating its encoding DNA, they do not need to express the protein. This invention further contemplates culturing transformed cells in a nutrient medium, thus permitting the protein to accumulate in the culture. The protein can be recovered either from the culture or from the culture medium.

For purposes of this invention, DNA sequences are operably linked when they are functionally related to each other. For example, DNA for a presequence or secretory leader is operably linked to a polypeptide if it is expressed as a preprotein or participates in directing the polypeptide to the cell membrane or in secretion of the polypeptide. A promoter is operably linked to a coding sequence if it controls the transcription of the polypeptide; a ribosome binding site is operably linked to a coding sequence if it is positioned to permit translation. Usually, 'operably linked' means contiguous and in reading frame; however, certain genetic elements such as repressor genes are not contiguously linked (or even closely linked) but still affect operator sequences that in turn control expression, and thus are indeed operably linked.

Suitable host cells include prokaryotes, lower eukaryotes, and higher eukaryotes. Prokaryotes include both gram negative and gram positive organisms, e.g., *E. coli* and *B. subtilis*. Lower eukaryotes include yeasts, e.g., *S. cerevisiae* and *Pichia*, and species of the genus *Dictyostelium*. Higher eukaryotes include established tissue culture cell lines from animal cells, which may be of non-mammalian origin, e.g., insect cells, and birds, or of mammalian origin, e.g., from humans, primates, or rodents.

Prokaryotic host-vector systems include a wide variety of vectors for many different species. As used herein, *E. coli* and its vectors will be used generically to include similar vectors used in other prokaryotes. A representative vector for amplifying DNA is pBR322 or many of its derivatives. Vectors that can be used to express the NKB1 proteins or its fragments include, but are not limited to, such vectors as those containing the lac promoter (pUC-series); trp promoter (pBR322-trp); Ipp promoter (the pIN-series); lambda-pP or pR promoters (pOTS); or hybrid promoters such as ptac (pDR540). See Brosius et al. (1988), "Expression Vectors Employing Lambda-, trp-, lac-, and Ipp-derived Promoters", in Rodriguez and Denhardt (eds.) Vectors: A Survey of Molecular Cloning Vectors and Their Uses, Butterworths, Boston, Chapter 10, pp. 205-236.

Lower eukaryotes, e.g., yeasts and *Dictyostelium*, may be transformed with vectors encoding NKB1 proteins. For purposes of this invention, the most common lower eukaryotic host is the baker's yeast, *Saccharomyces cerevisiae*. It will be used to generically represent lower eukaryotes, although a number of other strains and species are also available. Yeast vectors typically consist of a replication origin (except when the vector is of the integrating type), a selection gene, a promoter, DNA encoding the desired protein or its fragments, and sequences for termination of translation, polyadenylation, and termination of transcription. Suitable expression vectors for yeast include such constitutive promoters as 3-phosphoglycerate kinase and various other glycolytic enzyme gene promoters or such inducible promoters as the alcohol dehydrogenase-2 promoter or metallothionine promoter. Suitable vectors include derivatives of the following types: self-replicating low copy number (such as the YRp-series), self-replicating high copy number (such as the YEp-series), integrating types (such as the YIp-series), or mini-chromosomes (such as the YCp-series).

Higher eukaryotic tissue culture cells are the preferred host cells for expression of the functionally active NKB1 protein. In principle, many higher eukaryotic tissue culture cell lines are workable, whether from a vertebrate or invertebrate source, e.g., insect baculovirus expression systems. However, mammalian cells are preferred, for reasons of cotranslational and

posttranslational processing. Transformation or transfection and propagation of such cells has become a routine procedure. Examples of useful cell lines include HeLa cells, Chinese hamster ovary (CHO) cell lines, baby rat kidney (BRK) cell lines, insect cell lines, bird cell lines, and monkey (COS) cell lines. Expression vectors for such cell lines usually include an origin of replication, a promoter, a site for initiation of translation, RNA splice sites (if genomic DNA is used), a polyadenylation site, and a site for termination of transcription. These vectors also usually contain a selection gene or amplification gene. Suitable expression vectors may be plasmids, viruses, or retroviruses carrying promoters derived, e.g., from such sources as from adenovirus, SV40, parvoviruses, vaccinia virus, or cytomegalovirus. Representative examples of suitable expression vectors include pCDNA1; pCD, see, e.g., Okayama et al. (1985) Mol. Cell Biol. 5:1136-1142; pMC1neo Poly-A, see, e.g., Thomas et al. (1987) Cell 51:503-512; and a baculovirus vector such as pAC 373 or pAC 610.

It will often be desired to express an NKB1 protein polypeptide in a system which provides a specific or defined glycosylation pattern. In this case, the usual pattern will be that provided naturally by the expression system. However, the pattern will be modifiable by exposing the polypeptide, e.g., an unglycosylated form, to appropriate glycosylating proteins introduced into a heterologous expression system. For example, the NKB1 protein gene may be co-transformed with one or more genes encoding mammalian or other glycosylating enzymes. Using this approach, certain mammalian glycosylation patterns will be achievable or approximated in prokaryote or other cells.

The NKB1 protein, or a fragment thereof, may be engineered to be linked through phosphatidyl inositol to a cell membrane, but can be removed from membranes by treatment with a phosphatidyl-inositol-cleaving enzyme, e.g., phosphatidyl inositol phospholipase-C. This releases the antigen in a biologically active form, and allows purification by standard procedures of protein chemistry. See, e.g., Low (1989) Biochim. Biophys. Acta 988:427-454; Tse et al. (1985) Science 230:1003-1008; and Brunner et al. (1991) J. Cell Biol. 114:1275-1283.

Now that the NKB1 protein has been described, fragments or derivatives thereof can be prepared by conventional processes for synthesizing peptides. These include processes such as are described in Stewart and Young (1984) Solid Phase Peptide Synthesis, Pierce Chemical Co., Rockford, IL; Bodanszky and Bodanszky (1984) The Practice of Peptide Synthesis, Springer-Verlag, New York; and Bodanszky (1984) The Principles of Peptide Synthesis, Springer-Verlag, New York.. For example, an azide process, an acid chloride process, an

acid anhydride process, a mixed anhydride process, an active ester process (using, for example, a 4-nitrophenyl ester, N-hydroxysuccinimide ester, or cyanomethyl ester), a carbodiimidazole process, an oxidative-reductive process, or a dicyclohexylcarbodiimide additive process can be used. Solid-phase and solution-phase syntheses can both be used in the foregoing processes.

The NKB1 protein, fragments, or derivatives are suitably prepared in accordance with the above processes as typically employed in peptide synthesis, generally either by a so-called stepwise process which comprises condensing an amino acid to the terminal amino acid, one-by-one in sequence, or by coupling peptide fragments to the terminal amino acid. Amino groups that are not being used in the coupling reaction are typically protected to prevent coupling at an incorrect location.

If a solid-phase synthesis is adopted, the C-terminal amino acid is bound to an insoluble carrier or support through its carboxyl group. The insoluble carrier is not particularly limited as long as it has a binding capability to a reactive carboxyl group. Examples of such insoluble carriers include halomethyl resins, such as chloromethyl resin or bromomethyl resin, hydroxymethyl resins, phenol resins, tert-alkyloxycarbonyl-hydrazidated resins, and the like.

The peptide is synthesized step-by-step through condensation of the reactive amino group of the already-formed peptide or chain with the activated carboxyl group of the next amino acid (which is protected at its amino group). After the complete sequence has been synthesized, the peptide is split off from the insoluble carrier. This solid-phase approach is generally described by Merrifield et al., (1963) in J. Am. Chem. Soc. 85:2149-2156.

The prepared protein and fragments thereof can be isolated and purified from the reaction mixture by means of peptide separation, for example, by extraction, precipitation, electrophoresis and various forms of chromatography, and the like. The NKB1 proteins of this invention can be obtained in varying degrees of purity depending upon their desired use. Purification can be accomplished by use of the protein-purification techniques disclosed herein or by the use of the antibodies herein described in immunoabsorbant affinity chromatography. This immunoabsorbant affinity chromatography is typically carried out by first linking the antibodies to a solid support and then contacting the linked antibodies with solubilized lysates of appropriate source cells, lysates of other cells expressing the protein, or lysates or supernatants of cells producing the NKB1 protein as a result of DNA techniques; see below.

Uses

The present invention provides reagents which will find use in diagnostic applications as described elsewhere herein, e.g., in the general description for physiological or developmental abnormalities, or below in the description of kits for diagnosis.

This invention also provides reagents with significant therapeutic value. The NKB1 protein (naturally occurring or recombinant), fragments thereof, and antibodies thereto, along with compounds identified as having binding affinity to NKB1 protein, will be useful in the treatment of conditions associated with abnormal or undesired physiology or development, including abnormal proliferation, e.g., cancerous conditions, or degenerative conditions. Abnormal or undesired proliferation, regeneration, degeneration, and atrophy may be modulated by appropriate therapeutic treatment using the compositions provided herein. For example, a disease, disorder, or undesired response associated with expression or signaling by an NKB1 antigen should be a likely target for an agonist or antagonist of the protein.

In particular, NK cell function is important in mediating rejection of transplans, e.g., of bone marrow grafts and other tissues. The DX9 has been shown to block activation of various NK cells. Thus, other binding compositions, e.g., antibodies, which block NKB1 signal function will be useful in modulating tissue rejection or graft *v.* host responses, and may also be useful in controlling such conditions as autoimmune responses.

Other abnormal developmental conditions are known in the cell types shown to possess NKB1 antigen, e.g., NK cells and certain T cells. See Berkow (ed.) The Merck Manual of Diagnosis and Therapy, Merck & Co., Rahway, N.J.; and Thorn et al., Harrison's Principles of Internal Medicine, McGraw-Hill, N.Y.; and Frank et al. (eds.) (1995) Samter's Immunological Diseases, Little, Brown & Co., Boston.These problems may be susceptible to prevention or treatment using compositions provided herein.

Recombinant antibodies which bind to NKB1 can be purified and then administered to a patient. These reagents can be combined for therapeutic use with additional active or inert ingredients, e.g., in conventional pharmaceutically acceptable carriers or diluents, e.g., immunogenic adjuvants, along with physiologically innocuous stabilizers and excipients. These combinations can be sterile filtered and placed into dosage forms as by lyophilization in dosage vials or storage in stabilized aqueous preparations. This invention also

contemplates use of antibodies or binding fragments thereof, including forms which do not bind complement.

Screening using NKB1 for binding partners or compounds having binding affinity to NKB1 antigen can be performed, including isolation of associated components. Subsequent biological assays can then be utilized to determine if the compound has intrinsic biological activity and is therefore an agonist or antagonist in that it blocks an activity of the antigen. This invention further contemplates the therapeutic use of antibodies to NKB1 protein as antagonists. This approach will be particularly useful with other NKB1 protein species variants and other members of the family.

The quantities of reagents necessary for effective therapy will depend upon many different factors, including means of administration, target site, physiological state of the patient, and other medicants administered. Thus, treatment dosages should be titrated to optimize safety and efficacy. Typically, dosages used *in vitro* may provide useful guidance in the amounts useful for *in situ* administration of these reagents. Animal testing of effective doses for treatment of particular disorders will provide further predictive indication of human dosage. Various considerations are described, e.g., in Gilman et al. (eds.) (1990) Goodman and Gilman's: The Pharmacological Bases of Therapeutics, 8th Ed., Pergamon Press, Tarrytown, N.Y.; and Remington's Pharmaceutical Sciences 17th ed. (1990), Mack Publishing Co., Easton, Penn. Methods for administration are discussed therein and below, e.g., for oral, intravenous, intraperitoneal, or intramuscular administration, transdermal diffusion, topical administration, and others. Pharmaceutically acceptable carriers will include water, saline, buffers, and other compounds described, e.g., in the Merck Index (Merck & Co., Rahway, New Jersey). Dosage ranges would ordinarily be expected to be in amounts lower than 1 mM concentrations, typically less than about 10 μM concentrations, usually less than about 100 nM, preferably less than about 10 pM (picomolar), and most preferably less than about 1 fM (femtomolar), with an appropriate carrier. Slow-release formulations or a slow-release apparatus will often be utilized for continuous administration. See, e.g., Langer (1990) Science 249:1527-1533.

NKB1 protein, fragments thereof, and antibodies to it or its fragments, antagonists, and agonists, may be administered to the patient either as such or (depending on the size of the compounds) conjugated to carrier proteins such as ovalbumin or serum albumin prior to their administration. Therapeutic formulations may be administered in many conventional dosage formulations. Although the active ingredient can be administered alone, it is preferable to

present it as a pharmaceutical formulation. Formulations typically comprise at least one active ingredient, as defined above, together with one or more acceptable carriers therefor. Each carrier should be both pharmaceutically and physiologically acceptable in the sense of being compatible with the other ingredients and not injurious to the patient. Formulations include those suitable for oral, rectal, topical, nasal, or parenteral administration (including subcutaneous, intramuscular, intravenous and intradermal administration). The formulations may conveniently be presented in unit dosage form and may be prepared by any methods well known in the art of pharmacy. See, e.g., Gilman et al. (eds.) (1990) Goodman and Gilman's: The Pharmacological Bases of Therapeutics, 8th Ed., Pergamon Press, Tarrytown, NY; Remington's Pharmaceutical Sciences, 17th ed. (1990), Mack Publishing Co., Easton, Penn; Avis et al. (eds.) (1993) Pharmaceutical Dosage Forms: Parenteral Medications, Dekker, New York; Lieberman et al. (eds.) (1990) Pharmaceutical Doasage Forms: Tablets, Dekker, New York; and Lieberman et al. (eds.) (1990) Pharmaceutical Dosage Forms: Disperse Systems, Dekker, New York. The therapy of this invention may be combined with or used in association with other therapeutic agents.

Both the naturally occurring and the recombinant forms of the NKB1 proteins and the NKB1 specific antibodies of this invention are particularly useful in kits and assay methods which are capable of screening compounds for binding activity. Several methods of automating assays have been developed in recent years so as to permit screening of tens of thousands of compounds in a short period. See, e.g., Fodor et al. (1991) Science 251:767-773, which describes means for testing of binding affinity by a plurality of defined polymers synthesized on a solid substrate. The development of suitable assays can be greatly facilitated by the availability of large amounts of purified, soluble NKB1 protein as provided by this invention.

This invention is particularly useful for screening compounds by using recombinant antigen in any of a variety of drug-screening techniques. The advantages of using a recombinant protein in screening for specific ligands include: (a) an improved, reliable, specific and renewable source of the antigen; (b) potentially greater number of antigen molecules per cell giving better signal-to-noise ratio in assays; and (c) species variant specificity (theoretically giving greater biological and disease specificity). The purified protein may be tested in numerous assays, typically in *in vitro* assays, which evaluate biologically relevant responses. See, e.g., Coligan Current Protocols in Immunology; Hood et al. Immunology Benjamin/Cummings; Paul (ed.) (1993) Fundamental

Immunology; and Methods in Enzymology, Academic Press. This will also be useful in screening for a ligand which binds an NKB1, e.g., from an interacting cell.

One method of drug screening utilizes eukaryotic or prokaryotic host cells which are stably transformed with recombinant DNA molecules expressing the NKB1 antigens. Cells expressing an antigen in isolation from other functionally equivalent antigens can be isolated. Such cells, either in viable or fixed form, can be used for standard protein-protein binding assays. See also Parce et al. (1989) Science 246:243-247; and Owicki et al. (1990) Proc. Nat'l Acad. Sci. USA 87:4007-4011, which describe sensitive methods to detect cellular responses. Competitive assays are particularly useful, where the cells (source of NKB1 protein) are contacted and incubated with a labeled binding partner or antibody having known binding affinity to the ligand, such as ^{125}I-antibody, and a test sample whose binding affinity to the binding composition is being measured. The bound and the free labeled binding compositions are then separated to assess the degree of antigen binding. The amount of test compound bound is inversely proportional to the amount of labeled receptor binding to the known source. Numerous techniques can be used to separate bound from free antigen to assess the degree of binding. This separation step could typically involve a procedure such as adhesion to filters followed by washing, adhesion to plastic followed by washing, or centrifugation of the cell membranes. Viable cells could also be used to screen for the effects of drugs on functions mediated by NKB1 protein, e.g., second messenger levels, i.e., Ca^{++}; cell proliferation; inositol phosphate pool changes; and others. Some detection methods allow for elimination of a separation step, e.g., a proximity-sensitive detection method or system. Calcium-sensitive dyes will be useful for detecting Ca^{++} levels, with a fluorimeter or a fluorescence cell sorting apparatus.

Another method utilizes membranes from transformed eukaryotic or prokaryotic host cells as a source of NKB1 protein. These cells have been stably transformed with DNA vectors directing the expression of a membrane-associated NKB1 protein, e.g., an engineered membrane-bound form. Essentially, the membranes would be prepared from the cells and used in a receptor/ligand type binding assay such as the competitive assay set forth above.

Still another approach is to use either solubilized and unpurified NKB1 protein or solubilized and purified NKB1 protein from transformed eukaryotic or prokaryotic host cells. This allows for an easily quantifiable binding assay with

the advantages of increased specificity, the ability to automate, and high throughput of the test drug.

Another technique for drug screening involves an approach which provides high throughput screening for compounds having suitable binding affinity to NKB1 and is described in detail in International Patent Application no. WO 84/03564 (Commonwealth Serum Labs.), published on September 13, 1984. First, large numbers of different small peptide test compounds are synthesized on a solid substrate, e.g., plastic pins or some other appropriate surface. See Fodor et al. (1991). Then all the pins are reacted with solubilized and unpurified or with solubilized and purified NKB1 binding composition, and washed. The next step involves detecting bound binding composition.

Rational drug design may also be based upon structural studies of the molecular shapes of the NKB1 protein and other effectors or analogs. Effectors may be other proteins which mediate other functions in response to antigen binding, or other proteins which normally interact with the antigen, e.g., NKB1 ligand. One means for determining which sites interact with specific other proteins is a determination of the physical structure, e.g., by x-ray crystallography or two-dimensional NMR. This will provide guidance as to which amino acid residues form molecular contact regions. For a detailed description of protein structural determination, see, e.g., Blundell and Johnson (1976) Protein Crystallography, Academic Press, New York.

Purified NKB1 protein can be coated directly onto plates for use in the aforementioned drug-screening techniques. However, non-neutralizing antibodies to these ligands can be used as capture antibodies to immobilize the respective ligand on the solid phase.

Kits

This invention also contemplates use of NKB1 proteins, fragments thereof, peptides, their fusion products, and binding compositions in a variety of diagnostic kits and methods for detecting the presence of a binding composition. Typically the kit will have a compartment containing either a defined NKB1 peptide or gene segment or a reagent which recognizes one or the other, e.g., antigen fragments or antibodies. See, e.g., Chen (ed.) (1987) Immunoassay: A Practical Guide, Academic Press, Orlando, FL; Price and Newman (eds.) (1991), Principles and Practice of Immunoassay, Stockton Press, New York; and Ngo (ed.) (1988) Nonisotopic Immunoassay, Plenum Press, NY.

A kit for determining the binding affinity of a test compound to an NKB1 protein would typically comprise a test compound; a labeled compound, for example an antibody having known binding affinity for the antigen; a source of NKB1 protein (naturally occurring or recombinant); and a means for separating bound from free labeled compound, such as a solid phase for immobilizing the antigen. Once compounds are screened, those having suitable binding affinity to the antigen can be evaluated in suitable biological assays, as are well known in the art, to determine whether they exhibit similar biological activities to the natural antigen. The availability of recombinant NKB1 protein polypeptides also provides well-defined standards for calibrating such assays.

A preferred kit for determining the concentration of, for example, an NKB1 protein in a sample would typically comprise a labeled compound, e.g., antibody, having known binding affinity for the antigen, a source of antigen (naturally occurring or recombinant) and a means for separating the bound from free labeled compound, for example, a solid phase for immobilizing the NKB1 protein. Compartments containing reagents, and instructions, will normally be provided.

One method for determining the concentration of NKB1 protein in a sample would typically comprise the steps of: (1) preparing membranes from a sample comprising a membrane-bound NKB1 protein source; (2) washing the membranes and suspending them in a buffer; (3) solubilizing the NKB1 protein by incubating the membranes in a culture medium to which a suitable detergent has been added; (4) adjusting the detergent concentration of the solubilized antigen; (5) contacting and incubating said dilution with radiolabeled antibody to NKB1 protein to form complexes; (6) recovering the complexes such as by filtration through polyethyleneimine-treated filters; and (7) measuring the radioactivity of the recovered complexes.

Antibodies, including antigen-binding fragments, specific for the NKB1 protein or fragments are useful in diagnostic applications to detect the presence of elevated levels of NKB1 protein and/or its fragments. Such diagnostic assays can employ lysates, live cells, fixed cells, immunofluorescence, cell cultures and body fluids, and further can involve the detection of antigens related to the protein in serum, or the like. Diagnostic assays may be homogeneous (without a separation step between free reagent and protein-protein complex) or heterogeneous (with a separation step). Various commercial assays exist, such as radioimmunoassay, enzyme-linked immunosorbent assay (ELISA), enzyme immunoassay, enzyme-multiplied immunoassay technique, substrate-labeled fluorescent immunoassay, and the like. For example, unlabeled antibodies can

be employed by using a second antibody which is labeled and which recognizes the antibody to an NKB1 protein or to a particular fragment thereof. Similar assays have also been extensively discussed in the literature. See, e.g., Harlow and Lane (1988) Antibodies: A Laboratory Manual, CSH.

Anti-idiotypic antibodies may have similar use to diagnose presence of antibodies against an NKB1 protein, since antibodies against an NKB1 protein may be diagnostic of various abnormal states. For example, overproduction of NKB1 protein may result in various immunological reactions which may be diagnostic of abnormal physiological states, particularly in proliferative cell conditions such as cancer or abnormal differentiation.

Frequently, the reagents for diagnostic assays are supplied in kits, so as to optimize the sensitivity of the assay. Depending upon the nature of the assay for use with a kit of the present invention, its protocol and its label, there is provided labeled or unlabeled antibody, labeled or unlabeled binding partner, or labeled NKB1 antigen, – usually in conjunction with other additives, such as buffers, stabilizers, materials necessary for signal production such as substrates for enzymes, and the like. Preferably, the kit will also contain instructions for proper use and disposal of the contents after use. Typically the kit has compartments for each useful reagent. Desirably, the reagents are provided as a dry lyophilized powder, which may be reconstituted in an aqueous medium providing appropriate concentrations of reagents for performing the assay.

Any of the aforementioned constituents of the drug-screening and the diagnostic assays may be used without modification or may be modified in a variety of ways. For example, labeling may be achieved by covalently or non-covalently joining a moiety which directly or indirectly provides a detectable signal. In any of these assays, the antigen, test compound, NKB1 protein, or antibodies thereto can be labeled either directly or indirectly. Possibilities for direct labeling include label groups: radiolabels such as ^{125}I, enzymes such as peroxidase and alkaline phosphatase (see, e.g., U.S. Pat. No. 3,645,090), and fluorescent labels capable of monitoring the change in fluorescence intensity, wavelength shift, or fluorescence polarization (see, e.g., U.S. Pat. No. 3,940,475). Possibilities for indirect labeling include biotinylation of one constituent followed by binding to avidin coupled to one of the above label groups.

There are also numerous methods of separating the bound from the free antigen, or alternatively the bound from the free test compound. The NKB1 protein can be immobilized on various matrixes and then be eluted. Suitable matrixes include plastic such as an ELISA plate, filters, and beads. Methods of immobilizing the NKB1 protein to a matrix include, without limitation, direct

adhesion to plastic, use of a capture antibody, chemical coupling, and biotin-avidin. The last step in this approach involves the precipitation of protein-protein complex by any of several methods including those utilizing, e.g., an organic solvent such as polyethylene glycol or a salt such as ammonium sulfate. Other suitable separation techniques include, without limitation, the fluorescein antibody magnetizable particle method described in Rattle et al. (1984) Clin. Chem. 30:1457-1461, and the double-antibody magnetic particle separation as described in U.S. Pat. No. 4,659,678.

The methods for linking proteins or their fragments to the various labels are extensively reported in the literature and do not require detailed discussion here. Many of the techniques require activated carboxyl groups (through the use of either carbodiimides or active esters) to form peptide bonds, an activated halogen substituent (as in the chloroacetyl group) to form thioethers by reaction with a mercapto group, or an activated double bond (as in maleimide) for linkage, or the like. Fusion proteins will also find use in these applications.

Another diagnostic aspect of this invention involves use of oligonucleotide or polynucleotide sequences taken from the sequence of an NKB1 protein. These sequences can be used as probes for detecting levels of antigen message in samples from patients suspected of having an abnormal condition, e.g., cancer or developmental problem. The preparation of both RNA and DNA nucleotide sequences, the labeling of the sequences, and the preferred size of the sequences has received ample description and discussion in the literature. Normally an oligonucleotide probe should have at least about 14 nucleotides, usually at least about 18 nucleotides, and a polynucleotide probe may have up to several kilobases. Various labels may be employed, most commonly radionuclides, particularly ^{32}P. However, other techniques may also be employed, such as using biotin-modified nucleotides for introduction into a polynucleotide. The biotin then serves as the site for binding to avidin or antibodies, which may be labeled with a wide variety of labels, such as radionuclides, fluorescers, enzymes, or the like. Alternatively, antibodies may be employed which can recognize specific duplexes, including DNA duplexes, RNA duplexes, DNA-RNA hybrid duplexes, or DNA-protein duplexes. The antibodies in turn may be labeled and the assay carried out where the duplex is bound to a surface, so that when the duplex forms on the surface, the presence of antibody bound to the duplex can be detected. The use of probes to the novel anti-sense RNA may be carried out in any conventional techniques such as nucleic acid hybridization, plus and minus screening, recombinational probing,

hybrid released translation, and hybrid arrested translation. This also includes amplification techniques such as polymerase chain reaction.

Diagnostic kits which also test for the qualitative or quantitative presence of other markers are also contemplated. Diagnosis or prognosis may depend on the combination of multiple indications used as markers. Thus, kits may test for combinations of markers. See, e.g., Viallet et al. (1989) Progress in Growth Factor Res. 1:89-97.

Methods for Isolating NKB1 Specific Binding Partners

The NKB1 protein should interact with a ligand according to (e.g.) its similarity in structure and function to other cell markers exhibiting developmental and cell type specificity of expression. Methods to isolate a ligand are made available by the ability to make purified NKB1 for screening programs. Soluble constructs or other constructs using the NKB1 sequences provided herein will allow for screening or isolation of NKB1 specific ligands.

The broad scope of this invention is best understood with reference to the following examples, which are not intended to limit the invention to specific embodiments.

EXAMPLES

General Methods

Some of the standard methods are described or referenced in, e.g., Maniatis et al. (1982) Molecular Cloning, A Laboratory Manual, Cold Spring Harbor Laboratory, Cold Spring Harbor Press; Sambrook et al. (1989) Molecular Cloning: A Laboratory Manual (2d ed.) vols. 1-3, CSH Press, NY; Ausubel et al., Biology, Greene Publishing Associates, Brooklyn, NY; or Ausubel et al. (1987 and Supplements) Current Protocols in Molecular Biology, Greene/Wiley, New York; Innis et al. (eds.) (1990) PCR Protocols: A Guide to Methods and Applications, Academic Press, N.Y. Methods for protein purification include precipitation with ammonium sulfate, column chromatography, electrophoresis, centrifugation, crystallization, and others. See, e.g., Ausubel et al. (1987 and periodic supplements); Deutscher (1990) "Guide to Protein Purification" in Methods in Enzymology, vol. 182, and other volumes in this series; and manufacturer's literature on use of protein purification products, e.g., Pharmacia, Piscataway, N.J., or Bio-Rad, Richmond,

CA. Use together with recombinant techniques allows fusion to appropriate segments, e.g., to a FLAG sequence or an equivalent which can be fused via a protease-removable sequence. See, e.g., Hochuli (1989) Chemische Industrie 12:69-70; Hochuli (1990) "Purification of Recombinant Proteins with Metal Chelate Absorbent" in Setlow (ed.) Genetic Engineering, Principle and Methods 12:87-98, Plenum Press, N.Y.; and Crowe et al. (1992) QIAexpress: The High Level Expression & Protein Purification System, QIAGEN, Inc., Chatsworth, CA.

Cell culture techniques are described, e.g., in Doyle et al. (1994 and periodic supplements) Cell and Tissue Culture: Laboratory Protocols, Wiley and Sons, NY. FACS analyses are described in: Melamed et al. (1990) Flow Cytometry and Sorting, Wiley-Liss, Inc., New York, NY; Shapiro (1988) Practical Flow Cytometry, Liss, New York, NY; and Robinson et al. (1993) Handbook of Flow Cytometry Methods, Wiley-Liss, New York, NY.

NK clones.

Normal human peripheral blood was purchased from the Stanford Blood Bank, Stanford, CA. NK cell clones ($CD3^-$,$CD56^+$) were established using the culture conditions described by Yssel et al. (1984) J. Immunol. Methods 72:219-227.

Monoclonal antibodies and flow cytometry.

Various mAbs were generously provided by Becton Dickinson Immunocytometry Systems, San Jose, CA. Cy-chrome™-conjugated anti-CD3 was purchased from Pharmingen, San Diego, CA. DX9 (IgG1) hybridoma was generated by immunizing Balb/c mice with human NK clone VL186-1 (a clone characterized as $CD3^-$,$CD16^+$,$CD56^+$) and fusing splenocytes with Sp2/0. Fab and $F(ab')_2$ fragments were prepared using respectively immobilized papain or immobilized pepsin (Pierce Chemicals, Rockford, IL), and intact mAb was removed by protein A affinity chromatography. Methods of immunofluorescent staining and flow cytometry have been described. See, e.g., Lanier et al. (1991) Methods: A Companion to Methods in Enzymology 2:192-199.

Biochemistry.

Viable cells were labeled with ^{125}I using lactoperoxidase/glucose oxidase or with ^{32}P-orthophosphate (Amersham, Arlington Heights, IL). See Lanier et al. (1988), J. Exp. Med., 167:1572-1585. Cells were lysed in Tris-

buffered saline (50 mM Tris, 15 mM NaCl, pH 8.0) containing 1% NP-40 and inhibitors of proteases and phosphatases, or 20 mM triethanolamine/150 mM NaCl buffer (pH 7.8) containing 1% digitonin (CalBiochem, La Jolla, CA) and 0.12% Triton X-100 (Sigma) with protease inhibitors. NKB1 antigen was immunoprecipitated as described by Lanier et al. (1988) J. Exp. Med. 167:1572-1585. NKB1 glycoprotein was treated with neuraminidase (Sigma), O-glycanase (Genzyme, Boston, MA), and N-glycosidase F (Boehringer Mannheim, Indianapolis, IN) according to the techniques provided by the manufacturers. Samples were analyzed by SDS-PAGE.

Cytotoxicity assays.

NK cell-mediated cytotoxicity was measured using a 4-hour ^{51}Cr-radio-isotope release assay at an effector to target ratio of 6:1 in the presence and absence of DX9 mAb (5 µg/ml). See, e.g., Lanier et al. (1983) J. Immunol. 131:1789-1796. C1R B-LCL (see, e.g., Edwards et al. (1982) Eur. J. Immunol. 12:641-648; and Zemmour et al. (1992) J. Immunol. 148:1941-1948) , and C1R transfectants expressing HLA-A*0201, -A*0301, -A*6801, -B*3701 and -B*5801 were generously provided by Dr. Peter Cresswell (Yale University, New Haven, CT) and Dr. Jeffrey Dawson (Duke University, Durham, NC). See, e.g., Storkus et al. (1992) J. Immunol. 149:1185-1190. 721.221 (see, e.g., Shimizu et al. (1989) J. Immunol. 142:3320-3328), and 721.221.B*5101 and 721.221.Cw*0301 transfectants were generously provided by Dr. Robert DeMars (University of Wisconsin, Madison, WI). 721.221 transfectants expressing HLA-A*0211, -A*3601, -B*3505,-B*4801, -B*5401, -B*5501, -B*5901, -Cw*0102, -Cw*0304, -Cw*0401, -Cw*0801, -Cw*1503 were generated as previously described. See Litwin et al. (1993) J. Exp. Med. 178:1321-1336.

Generation and characterization of DX9 mAb.

Whereas NK cell clones and polyclonal NK populations frequently kill MHC class I-deficient B-LCL C1R and 721.221, transfection with certain alleles of HLA-A, HLA-B, or HLA-C results in protection from NK cell lysis. In particular, certain alleles of HLA-B were recognized by a high frequency of NK clones. In order to identify NK cell receptors for HLA, mAbs were generated against an NK clone (VL186-1, described above) which was strongly inhibited from lysing HLA-B*5801-transfected B-LCL targets. See Litwin et al. (1993) J. Exp. Med.

178:1321-1336. In a hybridoma screening assay, mAb were selected which were able to induce lysis of HLA-B*5801 B-LCL-transfectants. NK clone VL186-1 normally does not kill the HLA-B*5801-transfected B-LCL (0% cytotoxicity). However, in the presence of mAb DX9, 64% lysis of the HLA-B*5801 transfected B-LCL was observed. DX9 mAb reacted with NK clone VL186-1, but failed to stain the HLA-B*5801-transfected B-LCL, indicating that the effect was due to interaction with the NK effector cell and not the target.

Fab and $F(ab')_2$ fragments of DX9 mAb were as efficient as intact Ig and induced lysis of the HLA-B*5801-transfected B-LCL at concentrations ranging from 0.3 μg/ml to 5 μg/ml.

The antigen recognized by DX9 mAb, designated NKB1, is present on a subset of $CD3^-$,$CD56^+$ NK cells in adult peripheral blood (Fig. 1), but is not expressed on granulocytes, monocytes, thymocytes, or B lymphocytes. Analysis of peripheral blood from 18 normal adult donors indicated that NKB1 is present on from <0.1% to 61% (mean = 14%) of $CD3^-$,$CD56^+$ NK cells. The significance of this heterogeneity is unknown. NKB1 was infrequently observed on adult peripheral blood $CD3^+$ lymphocytes, although a minor subset (<0.1 to 3%) of $NKB1^+$ T cells could be detected in certain persons. A panel of $NKB1^-$ and $NKB1^+$ NK clones ($CD3^-$,$CD56^+$) was established by single-cell cloning using flow cytometry for further analysis. In all cases, the NKB1 phenotype of the clones remained stable (representative clones are shown in Fig. 1). NK clones initially isolated as $NKB1^-$ have not been observed to acquire NKB1, nor have NK clones originally isolated as $NKB1^+$ been observed to lose NKB1.

<u>HLA specificity of NKB1.</u>

NK clones were established from two donors on the basis of NKB1 expression ($CD3^-$,$CD56^+$,$NKB1^+$ and $CD3^-$,$CD56^+$,$NKB1^-$). Of 29 $NKB1^+$ NK clones examined, all lysed HLA-deficient EBV-transformed B-LCL and demonstrated diminished lytic activity against HLA-B*5801 transfectants. Cytotoxicity against the HLA-B*5801 transfectant was substantially augmented in the presence of DX9 mAb with all $NKB1^+$ NK cell clones (see Table 2). By contrast, killing of the untransfected HLA-deficient EBV transformed B-LCL cell lines 721.221 and C1R by $NKB1^+$ NK clones was neither augmented nor inhibited by DX9 mAb. Examination of a broad panel of HLA transfectants indicated that DX9 mAb induced cytotoxicity against certain HLA-B alleles in addition to HLA-B*5801, but did not affect cytotoxicity against any HLA-C transfectants examined. Representative data from several $NKB1^-$ and $NKB1^+$

NK clones are summarized in Table 2. Whereas NKB1^{+} NK clones recognized and failed to lyse transfectants expressing certain HLA-C alleles (including -Cw*0102, -Cw*0301, -Cw*0304, -Cw*0401, -Cw*0801, -Cw*1503), the presence of DX9 mAb had no effect on the target protection conferred by these molecules.

TABLE 2. LYSIS OF HLA TRANSFECTED TARGET CELLS IN THE PRESENCE AND ABSENCE OF DX9 MAB.

A. DX9+ NK Clones

mAb	C1R transfectants				721.221 transfectants							
	B*3701		B*5801		B*5801		B*5101		Cw*0301		Cw*0401	
	none	DX9	none	DX9	none	DX9	none	DX9	none	DX9	none	DX9
A4	+[1]	+	–[2]	+	–	+	–	+	–	–	–	–
A6	+	+	–	+	nd[3]	nd	–	+	+	+	nd	nd
A7	+	+	–	+	–	+	–	+	–	–	–	–
A9	–	–	–	+	–	+	–	+	+	+	–	–
A21	+	+	–	+	–	+	–	+	+	+	–	–
A23	+	+	–	+	–	+	–	+	–	–	+	+
A26	+	+	–	+	–	+	–	+	–	–	–	–
A36	–	–	–	+	–	+	–	+	–	–	nd	nd

B. DX9– NK Clones

mAb	C1R transfectants				721.221 transfectants							
	B*3701		B*5801		B*5801		B*5101		Cw*0301		Cw*0401	
	none	DX9	none	DX9	none	DX9	none	DX9	none	DX9	none	DX9
B1	+	+	–	–	–	–	+	+	–	–	–	–
B2	–	–	–	–	+	+	+	+	+	+	–	–
B5	+	+	–	–	–	–	–	–	–	–	–	–
B6	+	+	–	–	nd	nd	+	+	+	+	nd	nd
B12	+	+	–	–	+	+	+	+	+	+	–	–
B19	+	+	–	–	nd	nd	+	+	+	+	nd	nd

1. '+' indicates that the % specific lysis of the HLA transfected target cell was comparable to that of the parental cell line or substantially increased in the presence of DX9 mAb. The data are a composite of several experiments.

2. '–' indicates that the % specific lysis of the HLA transfected target cell was 50% or less than that of the parental cell line, i.e., the NK clone recognizes that particular HLA allele.

3. Not determined.

This demonstrates that binding DX9 mAb to the NK clones does not interfere with recognition of all HLA molecules, but of only specific alleles. Since some NK clones have the ability to recognize multiple alleles of HLA-B, the effect of DX9 mAb on transfectants expressing B*0702, -B*2705, -B*3701, -B*4801, -B*5101, -B*5401, or -B*5501 was examined. It was consistently observed that DX9 mAb reversed the protection conferred by HLA-B*5101, in addition to HLA-B*5801 (see Table 2). HLA-B*5101 and -B*5801 are both within the Bw4 subgroup. DX9 mAb also affected recognition of HLA-B*2705. However, a lower frequency of NK clones recognized HLA-B*2705 compared to HLA-B*5101 and -B*5801 and the protection conferred by -B*2705 was less than with -B*5101 or -B*5801. Consistent with prior observations, NK clones recognizing B*0702, -B*3701, -B*4801, -B*5401, or -B*5501 and the HLA-A alleles (-A*0201, -A*0211, -A*0301, -A*3601, -A*6801) were less frequent than B*5801; however, preliminary studies indicated that DX9 mAb did not consistently or substantially affect lysis of these transfectants. Similar data were obtained using NKB1$^+$ NK clones derived from two independent donors.

Comparison of NKB1$^-$ and NKB1$^+$ NK clones derived from a single donor failed to reveal a strict correlation between the overall pattern of HLA specificity and NKB1 expression (Table 2). Moreover, many NKB1$^-$ NK cell clones recognized HLA-B*5801 and -B*5101, although, as expected, DX9 mAb failed to affect lysis of these transfectants. Thus, while the results are compatible with the possibility that NKB1 is a receptor for HLA-B*5801 and -B*5101, additional receptors with this specificity apparently are also present on NKB1$^-$ NK clones. NKB1$^-$ NK clones may express a variant of the molecule not recognized by the mAb or a distinct receptor which also recognizes HLA-B*5801 and -B*5101. That there was no apparent bias in the recognition of HLA-A or HLA-C alleles between the clones derived from the NKB1$^-$ and NKB1$^+$ NK subsets suggests the existence of independent receptors for these molecules.

<u>Structure of NKB1 antigen.</u>

DX9 mAb immunoprecipitated a 70 kD glycoprotein from ^{125}I labeled NKB1$^+$ NK cell clones that migrated as a single species using both reducing and non-reducing conditions. Similar results were obtained using 1% NP-40 or 1% digitonin detergent for cell disruption. Treatment with neuraminidase slightly decreased the mobility of NKB1, indicating the existence of sialic acid residues. Whereas endo H (endo-β-acetylglucaminidase H) and O-glycanase (endo-α-N-

acetylgalactosaminidase) failed to significantly affect NKB1, a core protein of ~50 kD was revealed after digestion with N-glycanase, demonstrating the presence of complex N-linked oligosaccharides. Immunoprecipitation from NK cell clones metabolically labeled with ^{32}P-orthophosphate indicated that NKB1 is constitutively phosphorylated. Stimulation with PMA neither increased nor decreased phosphorylation of NKB1.

Conclusions.

Analysis of NK clones using a broad panel of HLA transfectants has shown that multiple receptors for distinct HLA alleles or distinct groups of HLA alleles exist on human NK cells. The present studies show that NKB1 represents one of the NK receptors specific for certain alleles of HLA-B. Several observations demonstrate that NK cell recognition of HLA is quite complex. First, an individual NK clone apparently can recognize HLA-A, HLA-B, and HLA-C and multiple alleles of each locus. If a sufficiently broad panel of transfectants is examined, recognition of the different alleles can segregate independently in different NK clones. This implies the existence of multiple NK receptors. This is clearly illustrated by comparing NKB1$^-$ and NKB1$^+$ NK clones. Whereas all NKB1$^+$ NK clones examined recognize HLA-B*5801, many NKB1$^-$ NK clones were also functionally inhibited by HLA-B*5801, indicating the presence of another HLA-B*5801 receptor on the NKB1$^-$ subset. Moreover, NKB1 appears to "cross-react" with HLA-B*5801, -B*5101, and possibly -B*2701.

It is striking that NKB1$^+$ NK cells were easily detected in donors who express or lack HLA-B*5801 or HLA-B*5101. The ability to isolate NKB1$^+$ NK clones from donors expressing HLA-B*5801 implies that both structures can be present on the same NK cell. Moreover, since NKB1$^+$ NK clones from a HLA-B*5801$^+$ donor efficiently lysed the HLA$^-$ 721.221 B-LCL, whereas killing of 721.221 was prevented by transfection with HLA-B*5801, these results indicate that if a "negative signal" is induced it is directional and only functional in the context of interaction between the NK cell and the target cell. Recent studies using NK cell lines reactive with HLA-C also support the concept that third-party cells (*i.e.*, cells other than the NK cell and the target cell) expressing inhibitory HLA alleles are unable to affect the interaction between an NK cell and a susceptible target.

A further level of complexity is introduced by the expression of NKB1 on only a subset of NK cells and the variable frequency of this subset in different

persons. A similar situation exists with expression of Ly-49 and 5E6, which are expressed only on a subset of NK cells in certain mouse strains. Similarly, the EB6 and GL183 antigens implicated in recognition of HLA-C also are expressed only on partially overlapping subsets of human NK cells. The biological rationale for multiple HLA receptors distributed on subsets of NK cells is presently unknown.

Prior studies have demonstrated a correlation between expression of EB6 and GL183 and target cell protection by HLA-C. Based on family studies and analysis of HLA-C transfectants, two NK target specificities (designated group 1 and group 2) have been defined based on recognition of certain HLA-C alleles differing at amino acids 77 and 80. NKB1 is clearly distinct both in specificity and in structure from the EB6 and GL183 antigens. Certain NKB1^{+} NK clones have the ability to recognize HLA-C alleles of the group 1 or 2 specificities. Both the EB6 / GL183 and NKB1 are structurally different from the murine Ly-49 receptors which are disulfide-linked homodimers. Furthermore, the 70 kD NKB1 glycoprotein is substantially larger than EB6 and GL183, which migrate at 58 kD. The data are compatible with the existence on a single NK clone of distinct NK receptors for HLA-B and HLA-C that function independently.

The present invention thus indicates that there are specific antigens important in interaction and/or recognition of specific HLA subtypes of HLA-A, HLA-B, or HLA-C. Herein are provided HLA-B specific reagents, e.g., for HLA-B*5801 and HLA-B*5101. Specific HLA-A and/or HLA-C reagents should also exist.

<u>Isolating a Nucleic Acid Encoding an NKB1.</u>

Numerous methods are available to isolate a gene encoding a purified protein, especially where antibodies exist which recognize the protein. One method is to design methods for purification of the protein to determine peptide sequences. Given sufficient sequence information, and using redundant oligonucleotides, PCR or hybridization techniques will allow for isolation of genes encoding NKB1 proteins.

Another alternative is to generate additional antibodies to NKB1 proteins. These antibodies are applicable in "panning" techniques, such as described by Seed and Aruffo (1987) <u>Proc. Nat'l Acad. Sci. USA</u> 84:3365-3369. Phage-expression techniques are also applicable to screen cDNA libraries derived from appropriate NK or T cell subpopulations enriched for NKB1 expression. Glycosylation interference with antibody recognition will be generally less

problematic in the phage-selection systems. Cell-sorting techniques on a mammalian expression library are applicable also.

Another method for screening an expression library is to use antibody to screen successive subpopulations of libraries. The following provides one method of screening using small populations of cells on slides stained by a specific labeling composition, e.g., an antibody.

For example, on day 0, precoat two-chamber PERMANOX slides with 1 ml per chamber of fibronectin, 10 ng/ml in PBS, for 30 min at room temperature. Rinse once with PBS. Then plate COS cells at (2-3) x 10^5 cells per chamber in 1.5 ml of growth media. Incubate overnight at 37°C.

On day 1 for each sample, prepare 0.5 ml of a solution of 66 µg/ml DEAE-dextran, 66 µM chloroquine, and 4 µg DNA in serum-free DME. For each set, prepare a positive control, e.g., of human IL-10-FLAG cDNA construct at 1 and 1/200 dilution, and a negative mock. Rinse cells with serum-free DME. Add the DNA solution and incubate 5 hours at 37°C. Remove the medium and add 0.5 ml 10% DMSO in DME for 2.5 min. Remove and wash once with DME. Add 1.5 ml growth medium and incubate overnight.

On day 2, change the medium. On day 3 or 4, fix and stain the cells. Rinse the cells twice with Hank's Buffered Saline Solution (HBSS) and fix in 4% paraformaldehyde/glucose for 5 min. Wash 3X with HBSS. The slides may be stored at -80°C after all liquid is removed. For each chamber, perform 0.5 ml incubations as follows. Add HBSS/saponin (0.1%) with 32 µl/ml of 1M NaN_3 for 20 min. Wash the cells with HBSS/saponin 1X. Add soluble antibody, e.g., DX9, to the cells and incubate for 30 min. Wash cells twice with HBSS/saponin. Add second antibody, e.g., Vector anti-mouse antibody, at 1/200 dilution, and incubate for 30 min. Prepare ELISA solution, e.g., Vector Elite ABC horseradish peroxidase solution, and preincubate for 30 min. Use, e.g., 1 drop of solution A (avidin) and 1 drop solution B (biotin) per 2.5 ml HBSS/saponin. Wash cells twice with HBSS/saponin. Add ABC HRP solution and incubate for 30 min. Wash cells twice with HBSS, second wash for 2 min, which closes cells. Then add Vector diaminobenzoic acid (DAB) for 5 to 10 min. Use 2 drops of buffer, 4 drops DAB and 2 drops of H_2O_2 per 5 ml of glass-distilled water. Carefully remove chamber and rinse slide in water. Air-dry for a few minutes, then add 1 drop of Crystal Mount and a cover slip. Bake for 5 min at 85-90°C.

Alternatively, the NKB1 proteins are used for affinity-purification of cells expressing the ligand or for sorting out such cells. See, e.g., Sambrook et al. or Ausubel et al.

Applicants deposited DX9 Hybridoma (producing DX9 Mab) under the Budapest Treaty (on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure) at the American Type Culture Collection, Rockville, Maryland, USA, on December 13th 1994 under the accession number HB 11775.

All references cited herein are incorporated herein by reference to the same extent as if each individual publication or patent application was specifically and individually indicated to be incorporated by reference.

Many modifications and variations of this invention can be made without departing from its spirit and scope, as will be apparent to those skilled in the art. The specific embodiments described herein are offered by way of example only, and the invention is to be limited only by the terms of the appended claims, along with the full scope of equivalents to which such claims are entitled.

CLAIMS:

1. An antibody or antigen binding fragment thereof, which binds specifically to a mammalian NKB1.

2. An antibody of Claim 1, wherein said mammal is a primate.

3. An antibody of Claim 1, wherein said antibody:
   a) is a monoclonal antibody;
   b) interferes with binding of DX9 to said mammalian NKB1; or
   c) carries a label, including a fluorescent label.

4. An antigen binding fragment of Claim 1 consisting essentially of:
   a) an Fab fragment;
   b) an $F(ab)_2$ fragment; or
   c) an F_V fragment.

5. A method of detecting a mammalian NKB1, comprising binding an antibody of Claim 1 to said NKB1.

6. A method of Claim 5, wherein:
   a) said antibody is a labeled antibody;
   b) said antibody is immobilized to a solid substrate;
   c) said NKB1 is expressed on a cell surface;
   d) said detecting allows isolation of a cell which comprises a nucleic acid which expresses said NKB1; or
   e) said detecting further allows purification of said NKB1.

7. A kit for detecting a mammalian NKB1, comprising a compartment containing an antibody of Claim 1.

8. A fluorescence immunoassay kit of Claim 7.

9. A method of modulating an immune function mediated by a cell expressing an NKB1 comprising contacting said cell with an antibody or antigen binding fragment thereof of Claim 1.

10. A method of Claim 9, wherein said modulation is blocking NK cell activation.

11. A method of Claim 9, wherein said modulation is specific for HLA-B mediated functions.

12. A method for analysing an NK cell population, comprising measuring the presence of NKB1.

13. A method of Claim 12, wherein said measuring is a quantitative determination.

14. A method of Claim 12, wherein said measuring is by measuring binding of an antibody to NKB1.

15. A substantially pure mammalian NKB1.

16. An NKB1 of Claim 15, purified by immunoaffinity.

17. An NKB1 of Claim 16, wherein said immunoaffinity is performed using an antibody which binds specifically to a mammalian NKB1.

18. An NKB1 of Claim 17, wherein said antibody is DX9.

19. A fragment of a mammalian NKB1 of Claim 15, wherein said fragment:
  a) expresses an immunological epitope of said NKB1; or
  b) modulates an immune response.

20. A fragment of Claim 19, wherein said immune response is mediated by an NK cell.

21. A fragment of Claim 20, wherein said NK cell is NKB1^{+}.

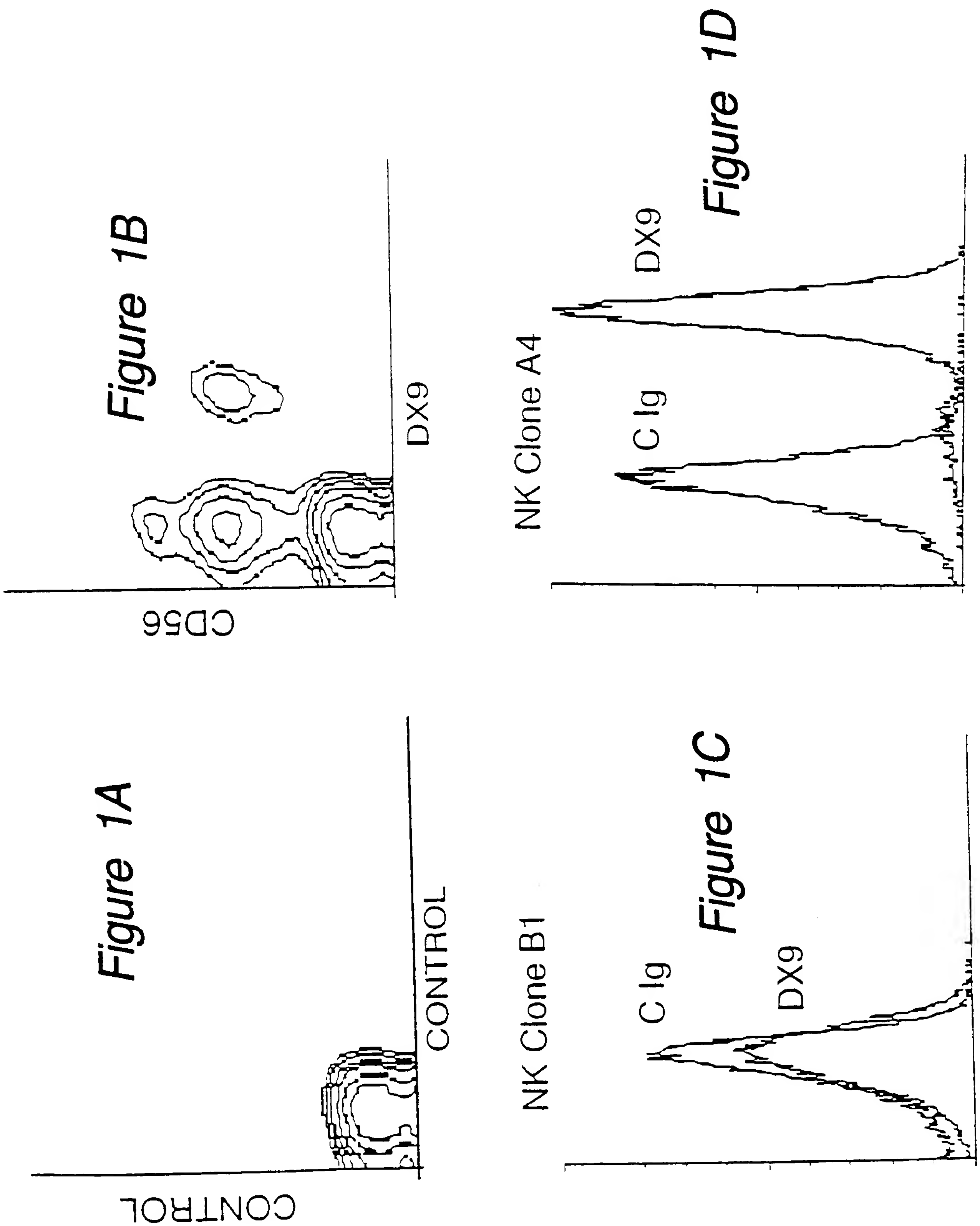

Figure 1A

Figure 1B

Figure 1C

Figure 1D

ERNATIONAL SEARCH REPO

International Application No
PCT/US 95/00552

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C07K16/28 C07K14/705 C12P21/08 G01N33/577 A61K39/395
//C12N15/12,C12Q1/68,C07K1/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C07K C12P G01N A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	THE JOURNAL OF EXPERIMENTAL MEDICINE, vol.178, no.4, 1 October 1993, NEW YORK, N.Y., US pages 1321 - 1336 V. LITWIN ET AL. 'SPECIFICITY OF HLA CLASS I ANTIGEN RECOGNITION BY HUMAN NK CLONES: EVIDENCE FOR CLONAL HETEROGENEITY, PROTECTION BY SELF AND NON-SELF ALLELES, AND INFLUENCE OF THE TARGET CELL TYPE.' cited in the application see the whole document ---	1-21

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[X] Further documents are listed in the continuation of box C.

[ ] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 June 1995	27. 06. 95
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+ 31-70) 340-3016	Authorized officer Ryckebosch, A

International Application No
PCT/US 95/00552

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	THE JOURNAL OF EXPERIMENTAL MEDICINE, vol.180, no.2, 1 August 1994, NEW YORK, N.Y., US pages 537 - 543 V. LITWIN ET AL. 'A NATURAL KILLER CELL RECEPTOR INVOLVED IN THE RECOGNITION OF POLYMORPHIC HLA-B MOLECULES.' see the whole document	1-21

INTERNATIONAL SEARCH REPORT

International application No
PCT/US 95/00552

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
Remark: Although claims 9-11 (at least partially as far as they concern an "in vivo method") are directed to a method of treatment of the human/animal body the search has been carried out and based on the alleged effects of the compound/composition.

2. [ ] Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searches without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.